

JACKSON MILLS & MINE FALLS DAMS

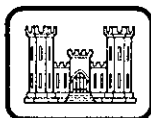
NASHUA, NEW HAMPSHIRE
HYDROELECTRIC FEASIBILITY

VOLUME 1

JACKSON MILLS DAM
RECONNAISSANCE REPORT

DECEMBER 1979

NEW
HAMPSHIRE



**United States Army
Corps of Engineers**

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NASHUA

New England Division

JACKSON MILLS AND MINE FALLS DAMS
NASHUA, NEW HAMPSHIRE

Reconnaissance Report
Hydroelectric Feasibility

VOLUME 1

JACKSON MILLS DAM

U. S. Army Corps of Engineers
New England Division
Waltham, MA

December 1979

EXECUTIVE SUMMARY

This study of hydroelectric development at Jackson Mills and Mine Falls Dams in Nashua, New Hampshire, is contained in two volumes: Volume 1 - Jackson Mills Dam and Volume 2 - Mine Falls Dam.

This report, Volume 1, has determined that reinstallation of hydroelectric power at Jackson Mills Dam is feasible. The New England Division's role in the project was to give technical assistance to the City of Nashua. This reconnaissance report will form the basis for any additional actions taken by the city for hydroelectric development.

Hydroelectric power was generated at Jackson Mills Dam until the 1950's. Then, cheap oil became readily available and the generating equipment was scrapped. The region's current dependence on expensive imported oil, however, has aroused new interest in using New England's numerous rivers for hydroelectric power. Senator John A. Durkin of New Hampshire requested this study of hydroelectric feasibility to once again use Jackson Mills Dam to generate electricity. Specific authority is contained in a resolution, dated 6 December 1978, by the U.S. Senate Committee on Environment and Public Works.

Jackson Mills Dam was built on the Nashua River in 1920 to operate the Jackson Mills. It is located in downtown Nashua, near the public library. The dam is now used by its owner, Sanders Associates, to maintain the water level for fire protection. The City of Nashua is in the process of acquiring the ownership of the dam and water rights.

Alternate sites, systems and marketing methods were evaluated during the study. Four alternatives for generating power at Jackson Mills Dam were evaluated. The architectural, aesthetic and equipment impacts were assumed to be equal for all four sites. Evaluation factors used in the decision-making process were ownership, construction access and impacts, and educational access for local groups of school children and adults.

The recommended alternative, a new powerhouse at the southern abutment adjacent to the public library, best met the evaluation criteria. This site would not have any of the ownership, construction or maintenance problems that the other sites have. Environmental impacts of the recommended alternative are expected to be short term and minimal. The site also provides easy access for educational purposes and coordination with the library.

The powerhouse would contain two horizontal shaft propeller turbines with runners of 1500-mm diameter, each capable of passing 460 cfs through an average head of 21 feet. The installed capacity is 1,300 Kw, and the average annual energy generation is estimated to be 5,450,000 Kwh. The plant would be operated as an automatic run-of-river installation with no manned control room.

Three possible marketing methods are discussed in this report: (1) Sale to the grid system of the total power produced, (2) Wheeling of power (Paying a utility for the use of its transmission lines), (3) Installing direct transmission lines, with provisions for standby power. The first plan, sale to the grid, would appear to be the best overall marketing method.

It was assumed for this analysis that the project would be funded and managed by the City of Nashua and that power would be sold directly to the Public Service Company of New Hampshire at the established rate of 4¢/Kwh. The project is expected to have a minimum life span of 40 years.

Total capital costs of the recommended plan are estimated at \$1.98 million. Annual operation and maintenance are estimated at \$34,600. Revenue from the sale of power is estimated to be \$218,000 annually. Using a 6-percent discount rate, the benefit-cost ratio of the recommended alternative is 1.31.

Another benefit to the city would be its ownership of an inflation-proof system: water is renewable and free. The hydroelectric power generated at the dam represents a savings in oil of 325,000 gallons each year.

Now that the Corps of Engineers' role has ended, the next step for the City of Nashua is procurement of a license from the Federal Energy Regulatory Commission (FERC).

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1.0 INTRODUCTION

1.1 Scope of Study

This study has investigated engineering and financial feasibility of reinstallation of hydroelectric power production at Jackson Mills on the Nashua River in Nashua, New Hampshire.

Alternative systems, sites, markets and finances were evaluated to select the most desirable and financially feasible system. The evaluation of financial feasibility was based on (a) hydrologic and hydraulic characteristics of the Nashua River and the damsite, and (b) the market value of generated power. The results of the foregoing analyses served as the primary bases for comparison of alternatives and ultimate selection of the recommended plan.

1.2 Authority

The authority for this study is contained in a resolution by the United States Senate Committee on Environmental and Public Works of 6 December 1978 at the request of Senator John A. Durkin of New Hampshire. A copy of this resolution is attached hereto in Appendix A.

1.3 Sources of Information

The Pre-Reconnaissance Report "Jackson Mills and Mine Falls Dams, Hydroelectric Feasibility", June 1979, prepared by Anderson-Nichols and Company, Inc. and the Corps of Engineers under Contract DACW33-78-C-0345 Work Order No. 4 formed the basis for this report.

Information was obtained from Federal agencies including, the U.S. Geological Survey, the Federal Insurance Administration, and the Federal Energy Regulatory Commission. At the state and local level, information was compiled from the New Hampshire Water Resources Board, Water Supply and Pollution Control Commission, Department of Resources and Economic Development, Fish & Game Department, the Governor's Council on Energy, the Public Utilities Commission, the Nashua Mayor's office, Assessor's office and Planning Board. Nongovernment sources including the Public Service Company of New Hampshire, Merrimack Valley Textile Museum, James River-Pepperell Inc. and the Energy Law Institute at the Franklin Pierce Law Center who provided useful information to this study. Their cooperation is appreciated.

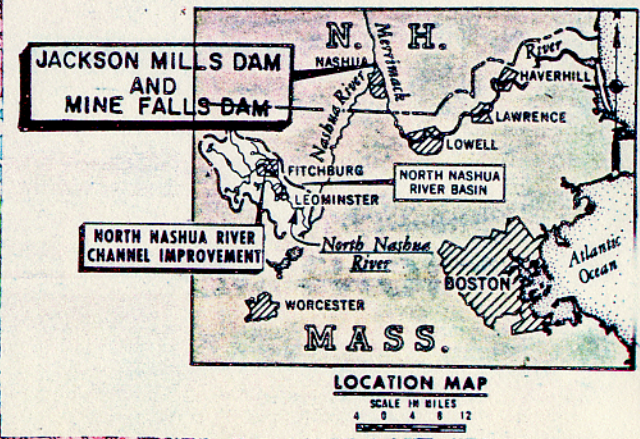
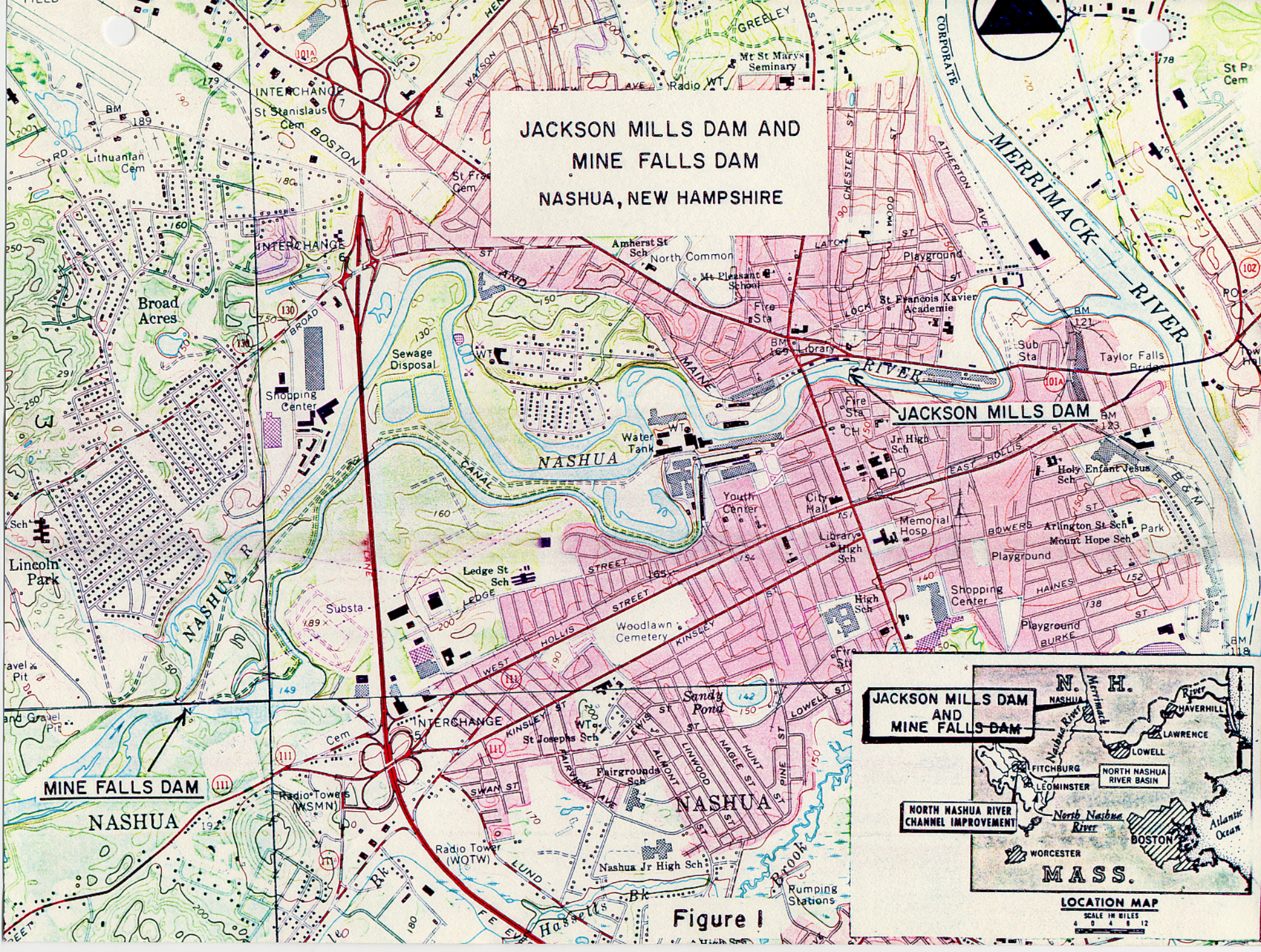


Figure 1

tion of the sluice gates may not be practical because of a new restaurant operation located in the old powerhouse. Recommended remedial operations include repair of the south abutment, removal and relaying of slope revetment on the down stream south bank, repair of the north abutment, and repair of the north wall in the forebay (Reference 1).

Jackson Mills Dam is highly visible in the downtown area. Careful consideration should be given to aesthetically landscape and design any structural changes to complement the architecture and scenery of the redeveloping area. Jackson Mills has strong potential educational value due to its proximity to the Nashua Public Library. The powerhouse could provide a viewing gallery with displays explaining salient facts about hydropower generation, historical points of interest at the site and simplistic general powerhouse descriptions. Jackson Mills Dam has the possibility of additional educational value if the site is developed for a solar and wood demonstration project proposed by Sanders Associates.

3.0 ENVIRONMENTAL SETTING

3.1 General

The Nashua River watershed includes 34 communities in Massachusetts and New Hampshire. The river is 57 miles long with the South Branch flowing from the Wachusett Reservoir in Clinton, MA where it continues north to Lancaster, MA joining the North Branch and forming the main stem. From here the river flows north to Nashua, NH, and ultimately into the Merrimack River. For three-fourths of its length it flows through country consisting of fields, wetlands and forests. (Reference 2).

Jackson Mills is located in downtown Nashua, NH, approximately 700 ft. downstream from the crossing of U.S. Rte 3 over the Nashua River. The area in the vicinity of the dam is urban in character and typical of an old New England manufacturing city. The Nashua Public Library is located on the south bank of the river. The former powerhouse on the opposite bank is presently the Chart House Restaurant which contains some of the original features of the old operation. Along both banks above and below the dam the vegetation consists of planted ornamentals and those types typical of disturbed ground.

3.2 Topography

The basin has a total drainage area of 529 square miles, with 88 square miles being in New Hampshire, and 441 square miles in Massachusetts.

The relief of the area varies with gentle slopes and low hills on the eastern side of the main stem valley, and steeper topography on the highland edge on the west. The Wachusett range divides the subwatershed of the southern region. The highest peak in the watershed is Mt. Wachusett with an elevation of 2,006 ft. (NGVD). (Reference 3).

From the central valley of the main stem of the Nashua River to the limits of the watershed, the landscape is broad, forested and rural, with small towns and cities scattered throughout.

The gradient of the river is gentle, with the main stem dropping 105 feet from Lancaster to the Merrimack River 35 miles downstream. (Reference 3).

3.3 Geology

The bedrock of the Nashua River watershed is mostly granite, and is covered with a mantle of soils, sand, gravel, and rock which was placed as glacial drift or as interglacial deposits. The basin is underlain by quartzites and schists which were metamorphosed during the collision of the North American and

European plates in the Early Paleozoic period, causing the general north-south orientation of the basin. (Reference 2).

In the central valley of the watershed, deep sand and gravel deposits are found at many places, including hardpan and bedrock in shallow areas.

Soils present in the watershed include clay, peat, and deep sandy loams. Most of the river has between 6 and 8 feet of sludge covering the bottom which may also extend a short distance up the banks at various places.

3.4 Water Quality

The entire length of the Nashua River in New Hampshire has been assigned an objective water quality standard of Class C by the New Hampshire Water Supply and Pollution Control Commission. Class C waters are suitable for boating, fishing and industrial water supply. Present water quality conditions in the river, however, do not meet the required criteria for Class C waters. Based upon data collected by the State of New Hampshire in 1977 and 1978 four miles upstream from Mine Falls Dam at Hollis, New Hampshire, high concentrations of total coliform bacteria and phosphorous are primarily responsible for the degradation. No data is available for the immediate area around the Jackson Mills Dam. The bacterial contamination is of both human and animal origins probably emanating from nonpoint sources and urban runoff. Concentrations of nitrogen and phosphorous are very high, and biological response is active with chlorophyll "A" levels typically about 30 mg/M³ and as high as 150 mg/M³. Daytime dissolved oxygen levels are always above 6 mg/l; pH varies within 0.5 units of neutrality; and suspended solids range up to 15 mg/l.

In support of the development of a water quality management plan for the Nashua River Basin, sediment sampling and analysis was performed in 1973 by Camp Dresser & McKee, Inc. at two sites behind Jackson Mills Dam. The survey revealed the existence of two types of PCB's, dieldrin, DDT and trace metals including aluminum, chromium, copper, mercury, lead and zinc in the sediments. The chlorinated hydrocarbons are very insoluble in water, with saturation concentrations of 1 to 2 (parts per billion), and toxic concentrations were not expected to exist in the water. The trace metals concentrations in the sediments were not expected to induce toxic conditions of metals release.

3.5 Climatology

The Nashua River watershed lies between 42° and 43° north latitudes with prevailing west to east winds, and northerly and southerly movements of tropical and polar air storm systems moving from west to east cause local variations in temperature and precipitation.

Normal annual precipitation at Nashua, NH, is 42 inches. Average annual snowfall is 58 inches. The mean winter and summer temperatures are 30°F and 70°F respectively.

3.6 Aquatic Ecosystem

The nearest Great Ponds (more than 10 acres) in the study area are in Hollis, NH, approximately eight miles south of Nashua. They are: (1) Flints Pond, 48 acres in size and private with no access or use; and (2) Rocky Pond, 46 acres in size and also private with no access or use.

The area of the Nashua River which includes the Jackson Mills Dam has not been stocked with trout by the N.H. Fish and Game Department. A short-term fishery investigation was conducted on the Nashua River by the State Fish and Game Department during the summer of 1974. Four stations were sampled downstream of the Mine Falls Dam in the area between the crossing of the Everett Turnpike and Runnell's Dam. The catch consisted of warmwater and non-game fish species, and was representative of those types of species which are found in the New Hampshire portion of the river. Brown and yellow bullheads were the most numerous species netted. (Reference 4). Table 1 lists those fish that were netted in the survey. It did not include any stations downstream from the Mine Falls Dam to the confluence of the Merrimack River.

Table 1

List of Fish Netted in the Nashua River, August 1974,

N. H. Fish and Game Department

Yellow Bullhead
Brown Bullhead
Black Crappie
Golden Shiner
Common Sunfish
Common White Sucker
Blue Gill
Yellow Perch
Carp

Ictalurus natalis
Ictalurus nebulosus
Pomoxis nigromaculatus
Notemigonus crysoleucas
Eupomotis gibbosus
Catostomus commersoni
Lepomis macrochirus
Perca flavescens
Cyprinus carpio

There is a potential to establish a fishery for small-mouth bass and related warmwater species. However, the water quality of the river must improve from its present state in order for management of a successful warmwater fishery.

In a subsequent survey performed in the summer of 1975, approximately 250 crayfish were live-trapped in the Nashua River at the Runnels Dam. (Reference 5). No other species were sampled for in this survey.

According to the Nashua River Watershed Association, the only areas in the watershed where gamefish are found are in the Nissitissit and Squannacook Rivers which are tributaries of the Nashua River, and are located south of Nashua, NH, in Pepperell and Townsend, MA, respectively. Rainbow trout, brook trout, brown trout, bass and pickerel are most commonly found in these rivers. However, the Nissitissit and Squannacook Rivers are well beyond the scope of the study area of Jackson Mills.

3.7 Terrestrial Ecosystem

Within the overall area of the watershed, the vegetative cover is primarily second-growth mixed hardwood/softwood forests. White pine, red pine, and hemlock are the common softwood species, and the common hardwood species include red maple, silver maple, white oak, willow, slippery elm and birch. In 1972, between 70 and 75 percent of the total area of the watershed consisted of forests and primarily wooded land. (Reference 3).

Common shrubs found along the streamsides and in wetlands are button bush, sweet viburnum, witch hazel, blueberry, alder, sumac, and marsh lady slippers.

Table 2 lists the types of vegetation found in the vicinity of Jackson Mills.

Table 2

Vegetation in the Vicinity of Jackson Mills

<u>Gleditsia triacanthos</u>	Honey Locust
<u>Acer saccharinum</u>	Silver maple
<u>Pinus nigra</u>	Austrian pine
<u>Crataegus spp.</u>	Hawthorns
<u>Rosa spp.</u>	Wild roses
<u>Ulmus americana</u>	American elm
<u>Rhus typhina</u>	Staghorn sumac
<u>Populus tremuloides</u>	Quaking aspen
<u>Juglans cinerea</u>	Butternut
<u>Sorbus aucuparia</u>	European mountain ash
<u>Malus sp.</u>	Ornamental crabapple
<u>Acer negundo</u>	Box elder
<u>Euonymus atropurpureus</u>	Burning bush
<u>Rubus sp.</u>	Raspberry
<u>Populus deltoides</u>	Common Cottonwood
<u>Catalpa bignonioides</u>	Common Catalpa
<u>Solidago sp.</u>	Goldenrod
<u>Aster novae - angliae</u>	New England Aster
<u>Acer saccharum</u>	Sugar Maple
<u>Ulmus rubra</u>	Slippery elm
<u>Solanum nigrum</u>	Common nightshade
<u>Acer platanoides</u>	Norway maple
<u>Cornus stolonifera</u>	Red-Osier Dogwood
<u>Morus mibra</u>	Red mulberry
<u>Lonicera tatarica</u>	Tartarian Honeysuckle
<u>Prunus sp.</u>	Cherry
<u>Quercus rubra</u>	Red Oak
<u>Fraxinis pennsylvanica</u>	Green Ash
<u>Peltandra virginica</u>	Arrow-Arum
<u>Salix sp.</u>	Willow
<u>Salix babylonica</u>	Weeping willow
<u>Acer rubrum</u>	Red Maple

The species found here are in general old field primary successional species that are indicative of an area that has previously been cut over and disturbed. Examples of these are goldenrod, nightshade, sumac and various species of grasses and ferns. Ornamentals are also prevalent, having been planted when the Nashua Public Library was built. These include crab apple trees, cherry trees and roses. The trees are small to medium in size, with the exception of a large red oak and a green ash directly behind the library next to the north end of the dam.

Small mammals are very common along the riverbank where development is not heavy and include raccoon, woodchuck and possibly otter and beaver. In the wooded areas, chipmunks, squirrels, mice, foxes and shrews are present.

Avifauna includes songbirds such as catbirds, chickadees, robins, nuthatches and others that typically inhabit city areas where food sources are available.

3.8 Cultural Resources

The existing dam at Jackson Mills consists of the following features (north to south):

A concrete-faced masonry retaining wall on the north bank, with a penstock gate to the Jackson Mills canal (now culverted).

A concrete and brick powerhouse structure built in 1919, and recently converted to a restaurant.

A concrete-faced masonry abutment between the former powerhouse and dam spillway.

The dam, of concrete capped masonry for 150 feet and concrete for 30 feet, of "gravity" design, with a spillway across the top.

The south abutment, of concrete-faced masonry, with riprap protection extending 500 feet downstream.

A masonry gravity dam existed at this site by 1877 (H.F. Walling, Atlas of New Hampshire. Comstock & Cline, New York. 1877), providing power for a sawmill and gristmill near the dam and the Jackson Mills downriver. In 1919, the powerhouse was built near the north bank and the dam was apparently rebuilt to a greater height. The concrete capping probably dates from this time or from possible modifications in the late 1930's.

The riverbank near the south abutment was apparently devoid of structures until the 20th century (Walling 1877; D.H. Hurd & Co. Town & City Atlas of the State of New Hampshire. Boston 1892). The slope of the bank today contains a large sewer interceptor, while the new library stands atop the terrace.

The considerable alterations to the dam during the 20th century have resulted in a structure which is visually more 20th than 19th century in character, while the lack of historic period structures and extensive modern disturbance on the south bank preclude preservation of significant prehistoric or historic archaeological resources in that area.

3.9 Rare and Endangered Species

The following plant species have been reported to be present at stations in the area of Nashua, NH. They are considered rare by the New England Botanical Club as reported in the 1978 publication from NEBC entitled: "Rare and Endangered Vascular Plant Species in New Hampshire." However, as some of the stations date back to the 1800's, the presence of these plants is questionable. They were not found in the vegetation surveys done for the listings provided in Table 2.

It should be noted that, at present, none of these are on the Federal list of endangered plants for this area or are they being proposed for inclusion on this list.

Zizania aquatica L. var. angustifolia Hitche - wildrice
Allium canadense L. - wild garlic
Prunus americana Marsh - American plum
Tephrosia virginiana L. Pers. - Goat's Rue
Xanthoxylum americanum Miller - Northern Prickly Ash
Viola pedata L. var. lineariloba DC - Birdfoot violet

No rare and/or endangered faunal species are known to exist in the vicinity of Jackson Mills.

4.0 HYDROLOGY

4.1 Watershed Description

The City of Nashua is located on the southern New Hampshire boundary approximately 12 miles north of Lowell, Massachusetts. The city straddles the Nashua River at its point of discharge to the Merrimack River. The city is located on a gently sloping low plateau that is characterized by stratified and unstratified material of silt, sand and gravel that were deposited by the meltwaters of a retreating glacial ice sheet. Elevations range from approximately 100 feet (NGVD) at the mouth of the river to 426 feet NGVD on Gilboa Hill, the highest point in town. The Nashua River basin has a total watershed area of 529 square miles located within the states of Massachusetts and New Hampshire. Portions of the watershed lie in the following counties: Worcester and Middlesex Counties, Massachusetts and Hillsborough County, New Hampshire. The Nashua River has two principal branches: the south or main branch originating north of Worcester at the Wachusett Reservoir Dam in Clinton and the north branch formed by the junction of the Whitman River and Flag Brook in West Fitchburg. The two branches join in Lancaster, Massachusetts, and flow north-easterly to the Merrimack River at Nashua, New Hampshire.

Though the gross watershed area of the Nashua River is 529 square miles, the Wachusett water supply reservoir diverts the runoff from 115 square miles, or 21 percent of the watershed, out of the basin to the Boston MDC water supply system. With the exception of very infrequent spillage, the only discharge from Wachusett Reservoir to the Nashua River is a prescribed minimum release of about 3 cfs. Therefore, the net effective drainage area of the Nashua River is 414 square miles. The most westerly headwater region of the watershed lies on the easterly slope of the "Berkshire" hills resulting in a hydrologically "flashy" North Nashua River. However, the mainstem Nashua River has a very flat gradient, for New England Rivers, with extensive swamps and natural valley storage areas, resulting in an overall hydrologically "sluggish" river basin.

The average annual temperature in the Nashua River basin is about 50° F varying from a seasonal average in the winter of about 30° to 70° in the summer. Extremes range from highs of near 100° F to lows in the minus 20°s. There are about 150 days per year with temperatures below 32° F. Average annual precipitation is about 42 inches, occurring quite uniformly throughout the seasons; however, some of the winter precipitation occurs as snow with an average annual snowfall of about 55 inches.

4.2 Streamflow

The average annual runoff in the Nashua River basin is about 24 inches or nearly 60 percent of annual precipitation. This amount of runoff is equivalent to an average runoff rate of between 1.7 and

1.8 cfs per square mile of drainage area, resulting in a total average flow at Nashua, from the net drainage area of 414 square miles, of about 730 cfs. Though precipitation is quite uniformly distributed throughout the year, the melting of the winter snow cover results in about 40 percent of the annual runoff during the spring months - March, April and May. Flows are usually lowest during July, August and September.

The U.S. Geological Survey has recorded flows on the Nashua River at East Pepperell, Massachusetts, (net drainage area equals 316 square miles) continuously since 1935. The long term average at this station is 557 cfs. Average monthly and maximum and minimum daily flows at the station site are listed in Table 3. The peak discharge at the gage was 20,900 cfs on 20 March 1936. The minimum flow was 1.1 cfs on 13 August 1939. A flow duration curve for the period of record (1936-1977) is shown in Figure B-1 (Appendix B). The four other flow-duration presented in Figure B-1 illustrate the wettest and driest years on record, 1956 and 1965, respectively, and the months of April and September for the period 1936-1971. These curves show the greater seasonal and annual variations in flow.

Because the study site at Nashua is located considerably downstream of the East Pepperell gaging station, with an intervening 89 square miles of drainage area, a flow duration curve at Nashua was developed based on the East Pepperell curve adjusted for the added area. Adjustment was based on intervening drainage area and mean basin elevation using the procedure presented by S.L. Dingman (Reference 6). This procedure resulted in lower flows at Nashua than would be computed using a ratio of net drainage area and was, therefore, considered a method providing conservative estimates for the purpose of this feasibility study. The adopted flow duration curve for the Nashua River at Nashua is shown as Figure B-2 (Appendix B). Although a small increase in drainage area occurs between Jackson Mills Dam and Mine Falls Dam, the same flow duration curve was considered applicable at both locations.

The foregoing flow analysis excludes consideration of flow maintenance required by the recently revised National Pollution Discharge Elimination System (NPDES) provisions for the river at the James River Pepperell Company just upstream of the USGS gage at East Pepperell, Massachusetts. According to the Company's NPDES permit, effective until February 1982, the James River - Pepperell Company is required to pass a minimum of 60 cfs or a flow into Pepperell Pond. Prior to 1977, their operation was required to pass approximately 15 cfs. Thus, it is possible that the low flow portion of the computed flow duration curve will change, however, any change would be in the very low flow range of the duration curve and should have no effect on the estimates of hydropower potential.

TABLE 3

AVERAGE MONTHLY FLOWS (1936-1977)
 NASHUA RIVER AT EAST PEPPERELL, MA

(Gross D.A. = 433 sq. mi.)

(Net D.A. = 316 sq. mi.)

<u>Month</u>	<u>Avg. Flow (cfs)</u>	<u>% of Annual Runoff</u>	<u>Maximum Daily</u>	<u>Minimum Daily</u>
Jan.	578	8.6	5,000	2.8
Feb.	616	9.2	4,160	6.7
Mar.	1,125	16.7	19,400	6.1
Apr.	1,247	18.6	5,340	5.5
May	720	10.7	2,780	5.5
June	454	6.8	6,840	3.5
July	260	3.9	4,550	5.2
Aug.	206	3.1	3,600	2.0
Sept.	242	3.6	9,790	3.6
Oct.	269	4.0	5,530	3.4
Nov.	442	6.6	4,090	3.7
Dec.	560	8.3	3,510	2.0
Annual	560		19,400	2.0

4.3 Hydropower Potential

The hydropower potential of a volume of water is the product of its weight and the vertical distance it can be lowered. Water power is the physical effect of the weight of falling water. It is considered a source of power when it can be feasibly harnessed to perform useful work - particularly turn wheels and generate electricity. The amount of water power developed from any stream, river, or lake is measured primarily by: (1) the available rate of water flow and (2) the head that is available. Both the rate of discharge and the head are quantities which may fluctuate. It is therefore the magnitude of these two quantities and their variability that determine the potential energy of a site and its dependability.

The rate of power generation, at any point in time, "capacity", normally measured in kilowatts, is determined by the classic formula:

$$P = \frac{EHQ}{11.8}$$

where:

- P = Power or capacity in kilowatts
- E = Combined turbine and generator efficiencies
- Q = Rate of discharge in cubic feet per second
- H = Net hydraulic head

The amount of power generation over a period of time, "energy", is normally measured in kilowatt-hours and is equal to the average capacity times the duration of generation.

All studies were made using an assumed average turbine-generator efficiency "E" of 80 percent and net head was taken as the difference between average head pool and tailwater, less any penstock friction loss.

Since the flow duration curve is a measure of the magnitude and variability of flow, the area under the flow duration curve - within the operating limits of the selected facility - establishes the potential average annual energy to be realized at a site. Examples of the computation of average annual energy and capacity are presented in Figures B-3 to B-5 (Appendix B).

Since the flow of the Nashua River at Nashua is quite variable and there is no appreciable regulating storage, the generating capacity at the sites could not be considered "firm" or "dependable" and energy generated would be classified as "fuel-saver" or "secondary". It is noted, however, that though the energy from the sites would not be firm, such generation would be "seasonally dependable" and could therefore be seasonally relied upon in the planned operation of a larger integrated system. For purposes of these studies, no capacity or firm energy benefit was claimed, and all benefits were based on a "secondary" power value of 40 mills per kwh.

5.0 HYDRAULIC TURBINE AND GENERATOR SELECTION

5.1 Hydraulic Turbine

There are two basic classes of hydraulic turbines - impulse turbines and reaction turbines. The fundamental difference is that impulse turbines are driven by the kinetic energy of a high velocity jet, whereas, reaction turbines are driven by the combined pressure and velocity of the water.

The impulse design has cost-effective operating characteristics for high heads (800 feet and higher) and, therefore, not suitable for the site in Nashua.

The reaction design includes two basic types of runners - Francis runners and propeller runners. A Francis runner operates at heads from 15 to 1100 feet. However, cost-effective operation requires a head of 100 feet or more, therefore, not suitable for Nashua. The propeller type operates at heads up to 100 feet but is usually cost-effective at heads at or below 60 feet (Reference 7). While early propeller runners had fixed position blades, it was not long before the advantages of being able to adjust the blade angles became recognized. This type of propeller runner is called a Kaplan runner.

With the limited head (less than 40 feet) and wide seasonal variation in flow at the site in Nashua, the most cost-effective unit is considered to be the Kaplan variable pitch blade propeller turbine.

Installation of the Kaplan turbine can be vertical or horizontal; the choice most often depends on head available or the site configuration. A very low head application is more effective for the vertical configuration as the units are often of large diameter and low speed, allowing less excavation for the powerhouse. The horizontal configuration places the drive shaft in the line of the flow through the runner; therefore, the generator must be also within or around the draft tube, or the flow must be diverted between the runner and generator with the drive shaft penetrating the draft tube. The bulb type system has the generator inside a steel bulb with runner downstream. The entire unit is contained within the draft tube. The bulb unit requires more excavation than other applications, and the flows available are at or below the lower limit of standard predesigned units. The application considered most appropriate for the Nashua site was the tube type, with the runner connected to the generator by a shaft penetrating the draft tube. It is available in standard predesigned units for applications involving a wide range of flows and heads encompassing conditions encountered at the site in Nashua.

Studies were made assuming one or two units per site as the flow of the river is too small to warrant additional construction and equipment costs for more units. However, two units per site are gen-

erally recommended due to the greater operating flexibility provided for the varying flow conditions. The upper and lower limit of effective operation of the units was assumed 100 and 50 percent of the design flow which is deemed conservative as present day variable blade units operate quite effectively at flows from 105 percent to less than 40 percent of design. Though the assumption is conservative, the large variation in flow and possible variations in head could reduce the overall average efficiencies of the units. Manufacturers indicate an efficiency of up to 85 percent. For purposes of this study, an average efficiency of 80 percent was assumed. It has also been assumed that in a multiple unit installation, all units will have variable blades, although a potential saving might be obtained if one unit is fixed blade and the other variable.

The selection of turbine size and hydraulic capacity was based on the head and flow characteristics at the site. The selected capacities were those of available "package" units that were considered reasonable levels of design providing realistic plant factors. Further optimization of selected installed capacity may result from more detailed design studies. However, use of available "package" type units should provide economies over custom designs. The selected capacities were at or near the 20 percent exceedance flow value, providing plant factors in the range of 35 to 50 percent. Characteristics of the tube type turbine and generator units were obtained from manufacturer literature that was generally representative of all major manufacturers.

Units with two turbines of unequal size allow for more efficient flow utilization and achieve higher plant factors. While equal-sized units permit slightly less efficient flow utilization, the analyses assume they provide economics of design, maintenance and operation which more than offset the incremental decrease in plant factor. Further in-depth investigations in any final design should be performed to verify these assumptions.

5.2 Generator Selection

Generators are either synchronous or induction types. The synchronous unit is equipped for self excitation and synchronization before going onto the grid, whereas, the induction generator relies on power from the grid for excitation. Induction generators are somewhat cheaper in cost and more applicable to small installations, however, for this feasibility study and at the suggestion of representatives of Public Service Company of New Hampshire, synchronous generators were assumed for the site.

6.0 MARKETING, FINANCING AND MANAGING HYDROPOWER ENERGY

6.1 Establishing a Potential Market

The ideal market for power produced would be to a facility whose electrical energy requirements would closely match the output of the proposed hydroelectric site. Since the plant is a run-of-the-river installation and dependent on the flow of the river, a backup of firm power would be required in the dry months, thus precluding a self-contained system.

Three possible plans are identified for the use of energy produced: (1) sale of total power produced to the grid system, (2) wheeling of power, and (3) direct transmission with provisions for standby power.

With regard to the sale of the total power produced to the grid system, current New Hampshire legislation states that the franchised utility shall buy the entire output of small hydro plants with the rate to be set by the Public Utilities Commission of New Hampshire (PUC). (Reference 8). An order by the PUC on April 18, 1979, set a rate of 4¢/KWH to be paid for the output of a run-of-the-river plant. (Reference 9). Excerpts from the above legislation are contained in Appendix C while the PUC order is contained in Appendix D.

Wheeling is the use of transmission lines owned by the electric utility to transmit power produced at the hydroelectric plant to a location where it can be used. A fee would be charged by the electric utility for this service. In Nashua's situation, this would mean that the power produced at Jackson Mills could be wheeled to City Hall, the Library, schools in the area or any other municipal building. Recent New Hampshire legislation allows the producer of small scale hydroelectric power to enter into a wheeling agreement with the franchised utility. The Public Utilities Commission of New Hampshire must approve such agreements. (Reference 10). Excerpts from the above legislation are contained in Appendix C. A source of backup power would still be required to firm up the power demanded by the buildings in the dry months. Thus, the City of Nashua could negotiate an agreement with Public Service Company of New Hampshire on wheeling and provisions for standby power.

Direct transmission would involve installing a separate independent grid from the site to distribute energy to the various municipal buildings in reasonable proximity to the site. This would require the installation of new distribution lines to the Nashua Public Library, City Fire Station and other designated municipal buildings. Since this would be a separate grid system, the City of Nashua would have to maintain this system. A source of standby power would also have to be provided for the dry months. At the present time, this marketing arrangement is inconsistent with New Hampshire Legislation.

Sale of the total power produced to the grid system would appear to be the best overall, since events in the State of New Hampshire are moving toward the stimulus of low-head hydropower production. The simple concept of selling generated hydropower to the Public Service Company through a single metered point provides a readily obtainable source of revenue and a market which can use the total energy generated.

6.2 Financing

The financial scenario developed for hydroelectric development at the site assumed that the City of Nashua would provide funding through 20-year bonds bearing an interest rate of approximately 6%, serviced with a sinking fund established for the life of the bond issue.

The ownership of the site by the City of Nashua, with its non-profit status might require prior clarification or interpretation from the Internal Revenue Service - since any income resulting from the production of hydropower might be taxable.

6.3 Management

It was assumed that the City of Nashua would manage the site, providing inspection, cleaning and maintenance of the trash racks and equipment; and that the operational control of the hydropower generating facility would be fully automatic with no manned control room. Emergency shutdown mechanisms would be provided for the safety and protection of the automatic equipment. Provisions could be incorporated that any technical or mechanical maintenance be performed by a technician provided by the manufacturer of the equipment, or under a service-type policy providing a specialist highly trained to service the equipment.

7.0 EXISTING WATER RIGHTS AND RESTRICTIONS

In New Hampshire, a developer of hydroelectric power, in acquiring his stream-bordering land, has also acquired certain riparian rights for usage of the water. These rights are outlined by the common law riparian doctrine of reasonable use. The ownership of the land bordering the stream gives a developer the right to use the water but not ownership of the water. Every owner of land situated adjacent to a stream who has not sold his water rights, has the right to the natural flow of the stream and to insist that the stream shall continue to run, that it shall flow off his land in its usual quantity, at its natural place and usual height and that it shall flow off his land upon the land below in its accustomed place and at its usual level. (Reference 11).

The City of Nashua is in the process of acquiring the ownership of Jackson Mills Dam and the flowage rights in the vicinity of the dam. The present deed to Jackson Mills Dam requires that the spillway crest not be raised above its present level, either permanently or temporarily and the level of the water not be lowered below the spillway. (Reference 12). The maintenance of the water level is required to provide enough head to maintain the flow of water for fire protection for Sanders Associates and the Nashua Corporation.

Therefore, the City of Nashua in the development of Jackson Mills Dam for hydroelectric generation cannot raise the dam above its present elevation and in the operation of a hydroelectric station has to maintain the water level sufficiently for fire protection requirements of Sanders Associates and the Nashua Corporation.

8.0 PROPOSED ALTERNATIVES

The City of Nashua is in the process of acquiring the ownership of Jackson Mills Dam and flowage rights in the vicinity of the dam. The dam is presently owned by Sanders Associates through Hi Tension Realty, and the former powerhouse is owned by a private individual who leases it to the Chart House Restaurant. The ownership of parts of the dam and appurtenances by separate parties poses a potential but not insurmountable problem for redevelopment of any hydropower facilities at this site. It was assumed for this analysis that ownership of the spillway, southern bank, abutment and water rights would be transferred to the City of Nashua and that ownership of the existing powerhouse will remain as it is at present. Any alternative which utilizes the existing powerhouse is contingent on an agreement with its owner relating to the use of facilities, design features and construction methods. The Nashua River is presently a Class C river by state water quality standards. Although a Class C river should not have significant quantities of game fish, a fishway might be required in the future. For purposes of this analysis, the provisions for or costs of a fishway are not included.

The Jackson Mills alternative hydropower generating sites were selected with the assumption that power production would be generated on or immediately adjacent to the existing dam and powerhouse. (See Plate 2, Appendix F).

Alternative A would utilize the existing powerhouse and intake facilities by making minor modifications to the existing structure.

Alternative B would provide for construction of a new powerhouse located immediately adjacent to and downstream of the existing powerhouse, making use of the intake facilities and turbine bays to transmit flow to the new powerhouse through an opening in the rear wall of the former powerhouse.

Alternative C would require a temporary breach of the northerly abutment of the dam between the existing powerhouse and the spillway and the construction of a new powerhouse at the breached section.

Alternative D would locate a new powerhouse and intake facilities next to the southern abutment adjacent to the grounds of the library.

Table 4 summarizes the alternatives for decision evaluation. The table assumes that any powerhouse or architectural considerations will affect each alternative equally. The evaluation has been performed by listing significant decision factors and rating each factor by degree of negative impact on the alternative. As there are only four alternatives, it was felt that slight, moderate and considerable impacts, given a ranking of one to three respectively,

TABLE 4
ASSESSMENT OF ALTERNATIVES

JACKSON MILLS DAM

<u>DECISION IMPACTS*</u>	<u>ALTERNATIVES</u>			
	A	B	C	D
Maintenance Access	3	2	2	1
Construction Access	1	2	3	1
Educational Access	3	2	3	2
Construction	1	2	3	3
Ownership	3	3	2	1
TOTAL	11	11	13	8

*Impact of architectural, aesthetic and equipment considerations have been assumed to be equivalent for each alternative.

Degree of Impact
 0 - None
 1 - Slight
 2 - Moderate
 3 - Considerable

could be totaled for each alternative. The alternative with the lowest total number would be evaluated and costed. The decision factors are: Ownership - the impact of which was discussed above; Construction - the impacts of dewatering the site, potential breaching of the dam, and need for new intake facilities; Construction Access - the impact of the site on physical construction methods; Maintenance Access - the impact of regular equipment inspection, maintenance and cleaning of trash racks; and Educational Access - the impact of visitation by groups of school children and adults from Nashua and the surrounding area.

This method of selection involved subjective consideration by the study team and resulted in the recommendation of Alternative D. The site would not have any of the ownership, construction and maintenance problems which the other alternatives have. The site provides simple access for educational purposes and coordination with the library. Figure 2 is an aerial photograph showing the location of the site.

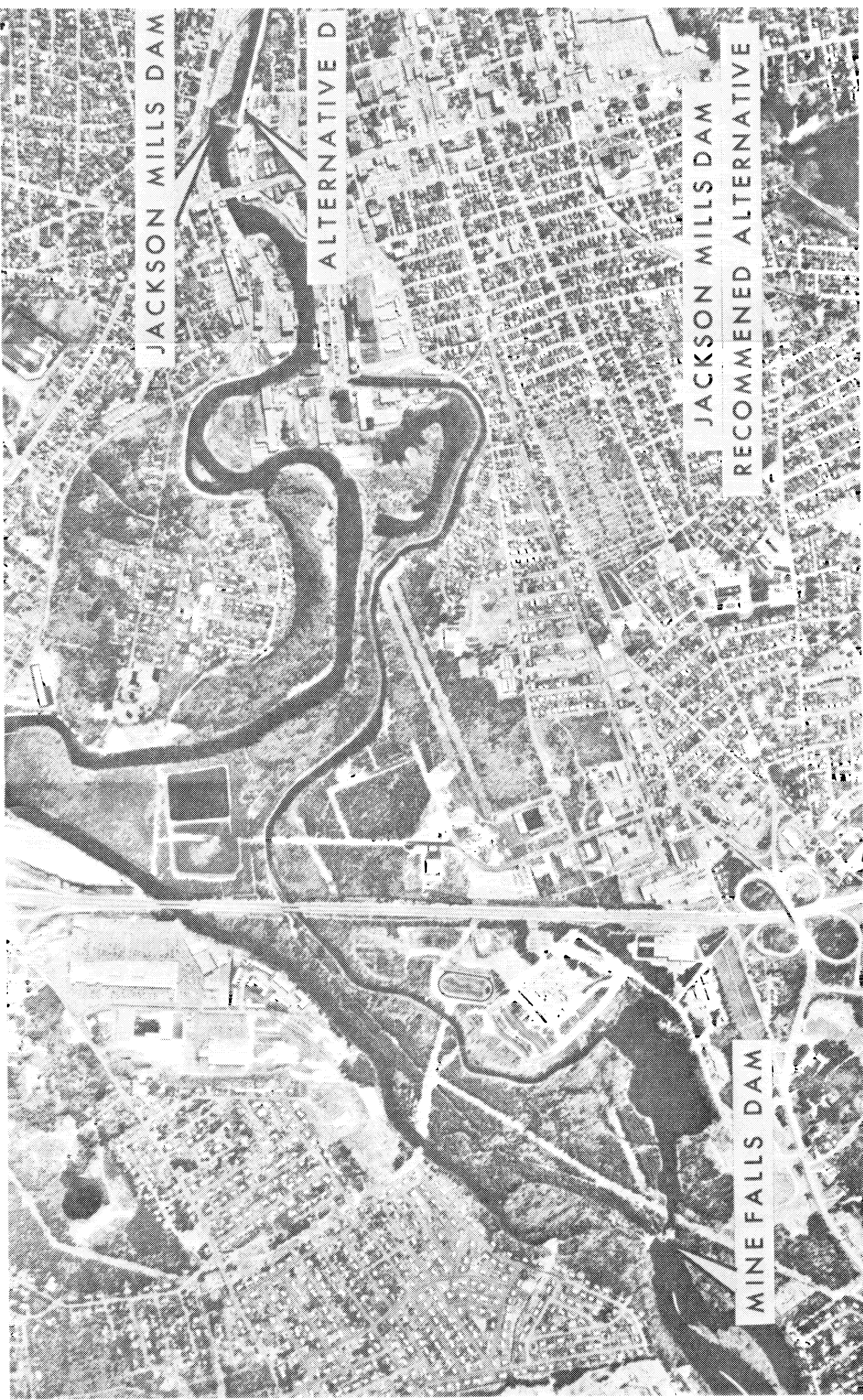


FIGURE 2

9.0 ENVIRONMENTAL CONSIDERATIONS OF THE ALTERNATIVES

General

For all alternatives associated with Jackson Mills, both proposed and recommended plans, the discussion of impacts are based on the fact that the dam would be operated as a run-of-the-river facility. The pool behind the dam would not normally be drawn down below the elevation of the spillway for purposes of power generation. The fluctuation of Jackson Mills Pool does not normally exceed 0.5 feet per hour. If the pool had to be used during an emergency situation during low flow periods, the pool would be drawn below spillway crest for a short period of time. This drawdown would not exceed 0.5 to 1 ft. per hour. (Refer to Section 10: Hydrologic Engineering Analysis for discussion of project operation). The level of the pond could be affected by low water during the summer months as a result of low rainfall.

Alternative A

This alternative, utilizing the existing powerhouse and intake facilities, would not result in any severe environmental impacts. Any impacts that would occur due to any construction activities would be temporary in nature, such as a short-term increase in turbidity in the waters above and below the dam. This would not seriously affect any populations of fish that may be present in this portion of the river. As construction work would be centralized within the existing powerhouse, no vegetation would be affected.

The existing powerhouse structure was built in the early 20th century, and is typical of numerous powerhouses built at that time and still in operation. It has undergone considerable modification in conversion to a restaurant and is unlikely to be eligible for nomination to the National Register of Historic Places. Therefore, reconversion for power production would be expected to have no effect upon significant cultural resources.

Alternative B

This alternative would include the construction of a new powerhouse located immediately adjacent to and downstream of the existing powerhouse utilizing its intake facilities. The new powerhouse would be constructed in the area of the restaurant parking lot. This area has been built on and utilized for many years, and has small shrubs and trees scattered alongside the bank of the river. This vegetation would be cut and removed for the powerhouse site and also for any access ways that would have to be made. Temporary siltation and turbidity could occur as a result of the closeness of construction activities to the river.

As with Alternative A, internal or external modifications to the powerhouse are unlikely to affect significant cultural resources.

There would be little, if any, effect on any fish that inhabit this section of the river.

Any small mammals which may utilize this river area for cover and feeding would be temporarily displaced during construction activities and possibly for a short time afterwards. Noise from the operating powerhouse could deter them from coming back into the area.

Alternative C

This alternative proposes construction of a new powerhouse at a breached section of the northerly abutment of the dam. The impacts associated with this alternative would be similar to those associated with Alternative B. Any shrubs or trees on the site would have to be removed primarily for construction access ways to the site. Turbidity and siltation would most likely result for the duration of construction. Existing fisheries in this portion of the river would not be impacted.

As with Alternative B, any small mammals which may utilize this river area for feeding may be temporarily displaced during construction activities.

Noise from the operation powerhouse would most likely keep small animals away. However, as the sites are located in downtown Nashua, there is not likely any large populations of small mammals that would be affected.

Though portions of the dam may date from the late 19th century, its present condition and appearance reflect considerable 20th century modifications, and the proposed addition of a powerhouse is expected to have no adverse effect upon significant cultural resources. However, photographic and/or graphic recording may be desirable if any fabric of earlier dams becomes visible during construction.

Recommended Alternative D. Construction of a Powerhouse at the South Riverbank

An accessway was constructed along this south bank when the existing sewerline was laid. This accessway would be utilized during construction of the powerhouse. At the end of this accessway in back of the library, the existing vegetation would have to be removed, including one large red oak and one large green ash on the riverbank. This includes also the planted ornamentals alongside the chainlink fence that extends from the end of the dam up the bank towards the back of the library.

Increased turbidity and siltation in the river would be evident for the duration of construction.

There is the possibility that resident wildlife in this area would be temporarily or permanently displaced, with some returning after construction is completed and the facility is operating. These species would include mice, shrews, squirrels, chipmunks, rabbits and raccoons. Noise from the powerhouse would discourage animals from returning to this area. Birds will also be affected to a minor extent. The bushes and trees provide cover and food which will no longer be available once the structure is completed. However, there is substantial vegetation around the pond and also downstream of the dam that could possibly provide alternate sources of food for those birds that are displaced from the construction site.

This displacement could put pressure on the existing mammal and avifaunal populations which are probably operating under maximum carrying capacity. Local increases in the surrounding populations would increase feeding in these areas and may eventually reduce productivity.

Fluctuations in the pool level could cause some unpleasant odors as a result of sections of the riverbanks being exposed. The water level change would not seriously affect fish in the pool. Any submergent and emergent vegetation growing in the fluctuation zone could possibly be desiccated as a result of being exposed to higher temperatures. These impacts would be minor as fluctuations due to the generation of power would occur in the same zone as fluctuations during freshets; i.e., not exceeding 0.5 feet per hour. Should fluctuations go up to 1 foot per hour, the above impacts would also be evident and would be minor in nature. These impacts would also apply to Alternatives A,B, and C equally.

As with Alternative C, modifications to the dam are not expected to adversely affect significant cultural resources. As the south bank has been heavily disturbed by construction of a sewer interceptor, powerhouse construction activity at this site is unlikely to affect significant archaeological resources. Also as with Alternative C, recording of any earlier engineering features within the present dam may be desirable.

10.0 HYDROLOGIC ENGINEERING ANALYSIS

10.1 Pertinent Data

The recommended plan for hydropower development at Jackson Mills, Alternative D, consists of a new powerhouse located on the right side of the river just downstream of the existing dam. To avoid excessive excavation and possible disturbance of an existing 84-inch sewer line, it is recommended that the powerhouse be situated both riverward and downstream of the right abutment of the dam with an "L" section of spillway provided to compensate for any required encroachment on the existing 180-foot spillway crest length. A general plan is shown as Plate 3 (Appendix F). Pertinent data on the recommended plan is listed in Table 5.

10.2 Installed Capacity

The recommended installation would consist of twin 1500 mm, variable blade, tube type turbines each capable of discharging 460 cfs at maximum blade angle under a head of 21 feet. The units would be equipped with synchronous generators with not less than 650 kw capacity each. The total hydraulic capacity would therefore be 920 cfs at a head of 21 feet capable of generating 1300 kw of power. The potential average annual "energy" production of the recommended plan would be 5,450,000 kwh, at a 0.47 plant factor. The twin 1500-mm units were recommended after a cursory analysis of both single and two unit installations of varying size. Pertinent information for a range of unit sizes and combinations is summarized in Table 6. Typical flow duration analyses are illustrated on Figures B-3 through B-5 (Appendix B).

As stated earlier, installations with two turbines of unequal size allow for more efficient flow utilization, however, it was assumed that equal sized units would provide economics of design, maintenance and operation which would more than offset any efficiencies in flow utilization. A comparative analysis of twin 1250, 1500 and 1750-mm units indicated that the twin 1250-mm and 1500-mm installations were about equal in economic feasibility; therefore, the twin 1500-mm installation, providing the greater energy, was adopted.

10.3 Project Operation

Discharge at the existing Jackson Mills dam is mainly over the 180 foot long spillway with some supplemental discharge through an outlet in the structure at the left abutment of the dam. The spillway crest is at elevation 115.6 ft. NGVD and the average flow of 600 to 700 cfs produces about 1 foot head on the dam creating an average head pool level of about 116.5 feet NGVD. Average seasonal fluctuations in the pool varies from about spillway crest (115.6 NGVD) to

TABLE 5
JACKSON MILLS
RECOMMENDED PLAN
PERTINENT DATA

1. Number of Units	2
2. Size of Units	1,500 mm
3. Hydraulic Head (ft)	21
4. Hydraulic Capacity per unit (cfs)	460
5. Total Hydraulic Capacity (cfs)	920
6. Generator Type	Synchronous
7. Generator Capacity	650 kw each - 1,300 kw Total
8. Potential Annual Generation	5,450,000 kwh
9. Plant Factor	0.47
10. Spillway Crest Elevation	115.6 NGVD
11. Spillway Length (ft)	180
12. Headwater Pool Area (acres)	60-80
13. Seasonal Variations in Pool Elevation	1 ft. + (116-117 NGVD)
14. Max. Variations in Pool Elevation	13 ft. + (115.6-128 in 1936)
15. Rate of Change in Stage	0.5 ft/hr
16. Maximum Pool Variations Due to Generation	1 ft.
17. Rate of Variation Due to Generation	0.5 to 1 ft/hr

TABLE 6

JACKSON MILLS SITE
TURBINE COMPARISONS

<u>Unit Size</u> (mm)	<u>Average Head</u> (feet)	<u>Hydraulic Capacity/Range</u> (cfs)	<u>Plant Factor</u>	<u>Annual Energy Potential</u> (kwh)	
2000	21	800/400	0.44	4,384,000	
2250	21	985/500	0.36	4,444,000	
750/1750	21	755/60	0.53	5,072,000	
750/2000	21	925/60	0.47	5,434,000	
1000/1750	21	840/100	0.53	5,555,000	
1000/2000	21	1010/100	0.46	5,830,000	
1250/1500	21	790/160	0.53	5,274,000	
1250/1750	21	955/160	0.48	5,780,000	
<u>1500/1500</u>	<u>21</u>	<u>920/230</u>	<u>0.47</u>	<u>5,450,000</u>	(Recommended)
1250/1250	21	640/160	0.59	4,726,000	
1750/1750	21	1240/310	0.37	5,825,000	

about 2 feet (117.6 NGVD) during the wetter spring runoff months. The peak level of the Jackson Mills Pool occurred in March 1936 with a head of 13.5 feet (129.1 NGVD). The tailwater at the dam during this flood, due to backwater from the Merrimack River, was 128.2 feet NGVD. In a recurring March 1936 flood, the tailwater level would be lowered 8 to 10 feet by the operation of the Corps of Engineers flood control reservoirs in the upper Merrimack River basin. Rates of rise and fall of the Jackson Mills Pool during freshets is usually gradual, normally not exceeding 0.5 feet per hour.

With the recommended hydropower installation, generating flows would range from a low of about 230 cfs to a high of 920 cfs. The project would be operated as a run-of-river project and when the natural riverflows were less than 230 cfs, generation would cease, which could be as much as 30% of the time. Similarly, riverflows in excess of 920 cfs would be spilled, which would be expected at least 20% of the time. The hydropower operation would have little effect on the normal seasonal fluctuation in the head pool. Fluctuations in the head pool level, as a result of a run-of-river hydropower operation, would be caused by the variations in loading on the plant. The head pool has a surface area of about 60 to 80 acres, and the maximum change in pool level as a result of the plant going from no load to full load would be in the order of 1 foot and could occur over a period of not less than 1 to 2 hours.

At no time would the pool normally be drawn below spillway crest for purposes of power generation. However, if during low flow periods the project were being used as "spinning reserve" and an emergency need for power developed, then it is conceivable that under such an emergency, the pool could be drawn below spillway crest for a very short period of time. Again, the maximum rate of such drawdown would not exceed 0.5 to 1 foot per hour.

Hydropower potential at the site was determined assuming all flows within the minimum and maximum capacity of the installation would be available for generation. If it were necessary to maintain some minimum flow over the spillway during all periods of generation, this would reduce the average annual energy potential of the site. It was determined, for example, that if a minimum flow of 100 cfs was to be passed over the spillway during generation, the potential average annual energy would be reduced about 20% from 5,450,000 to 4,570,000 kwh and the percent of time of no generation would increase from about 30% to more than 40%. Such operational restraints, if imposed, would have proportional impact on the economic feasibility of hydropower development at Jackson Mills.

11.0 RECOMMENDED ALTERNATIVE

11.1 Powerhouse Characteristics

The recommended plan for hydropower development at Jackson Mills (Alternative D) would locate a new powerhouse at the southern bank of the river just downstream of the existing dam adjacent to the grounds of the library. (See Figures 3 and 4). The powerhouse would contain two horizontal shaft propeller turbines with runners of 1500-mm diameter, each capable of passing 460 cfs through an average head of 21 feet with an installed capacity of 1300 KW. The average annual energy generation would be 5,450,000 KWH. The plant would be operated as an automatic run-of-river installation with no manned control room. Emergency shutdown mechanisms would be provided for the safety and protection of the automatic equipment. Maintenance would be limited to cleaning of trash racks and inspection of equipment to detect any problems.

11.2 Construction Methods and Materials

The powerhouse foundation would be cast-in-place concrete on adequate bearing. The powerhouse itself would be structural concrete floors and walls with a steel roof. Brick or appropriate facade material would be used to maintain aesthetic quality of the surroundings. The intake facilities would be cast-in-place concrete and covered, as necessary, to allow for indoor cleaning of the trash racks and manual operation of the gates. Trash racks would be standard steel bar racks inclined for ease of cleaning. The draft tubes would be twin 9-foot diameter pipes made of mill rolled steel, welded together on the site. The powerhouse would be located in the riverbed, sufficiently downstream of the existing spillway to allow for construction of a forebay. The forebay would be accessed to the flows of the main river by lowering a section of the top of the existing spillway. Current spillway capacity will be retained by designing the concrete forebay wall to function in a spillway capacity. The transmission line would be of the 4.16 KV class for transmission of power to a substation of the Public Service Company of New Hampshire.

11.3 Construction Schedule

A construction schedule is shown on Fig. 5. A period of six to eighteen months would precede the beginning of any construction or ordering of equipment once a decision to construct the project has been made. This period would be necessary to secure a FERC license to operate the power station. The construction period would begin in July since the late summer would be ideal for dewatering the site because of reduced summer flows. Once the construction began, work would be continuous except during the coldest winter months. The

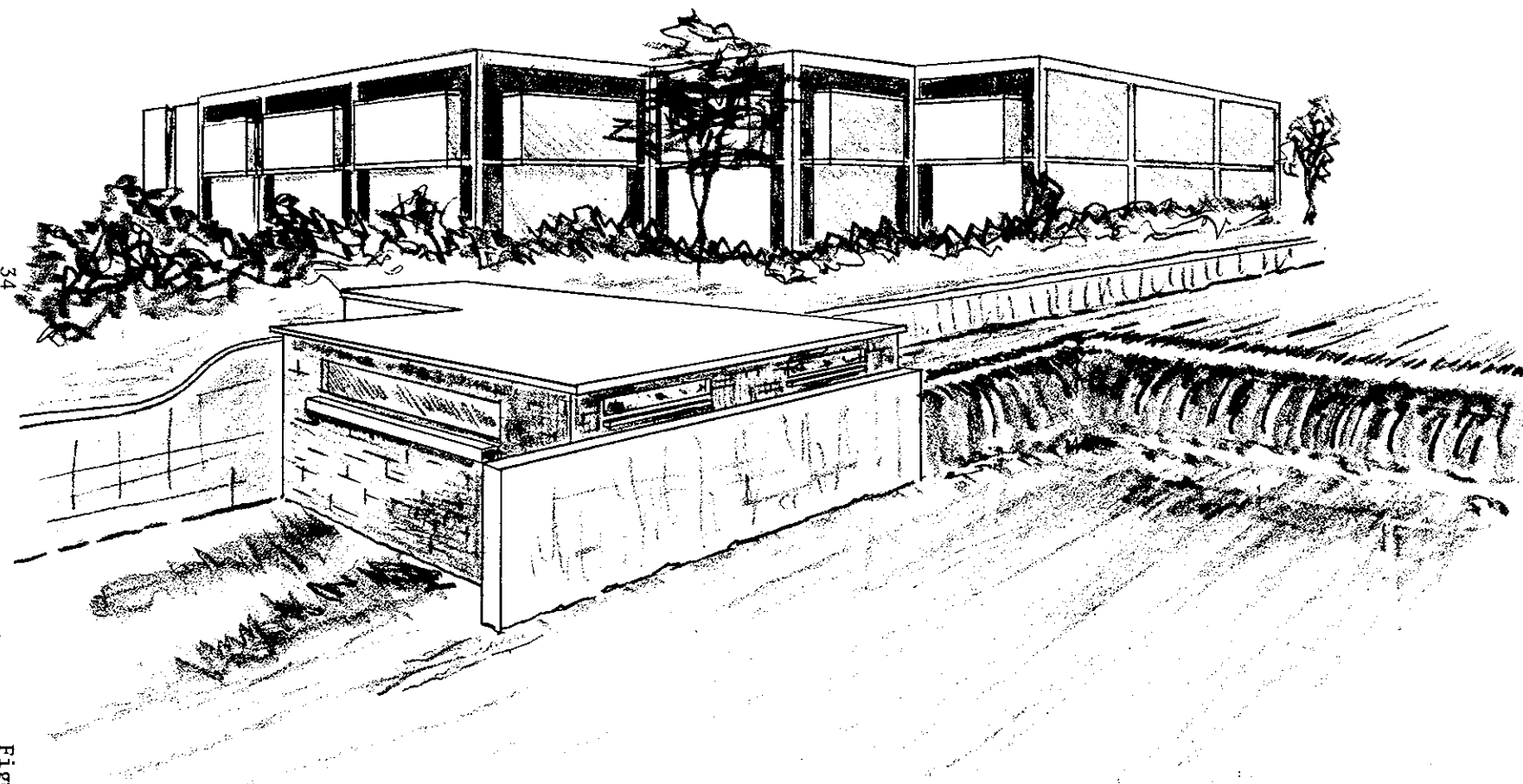
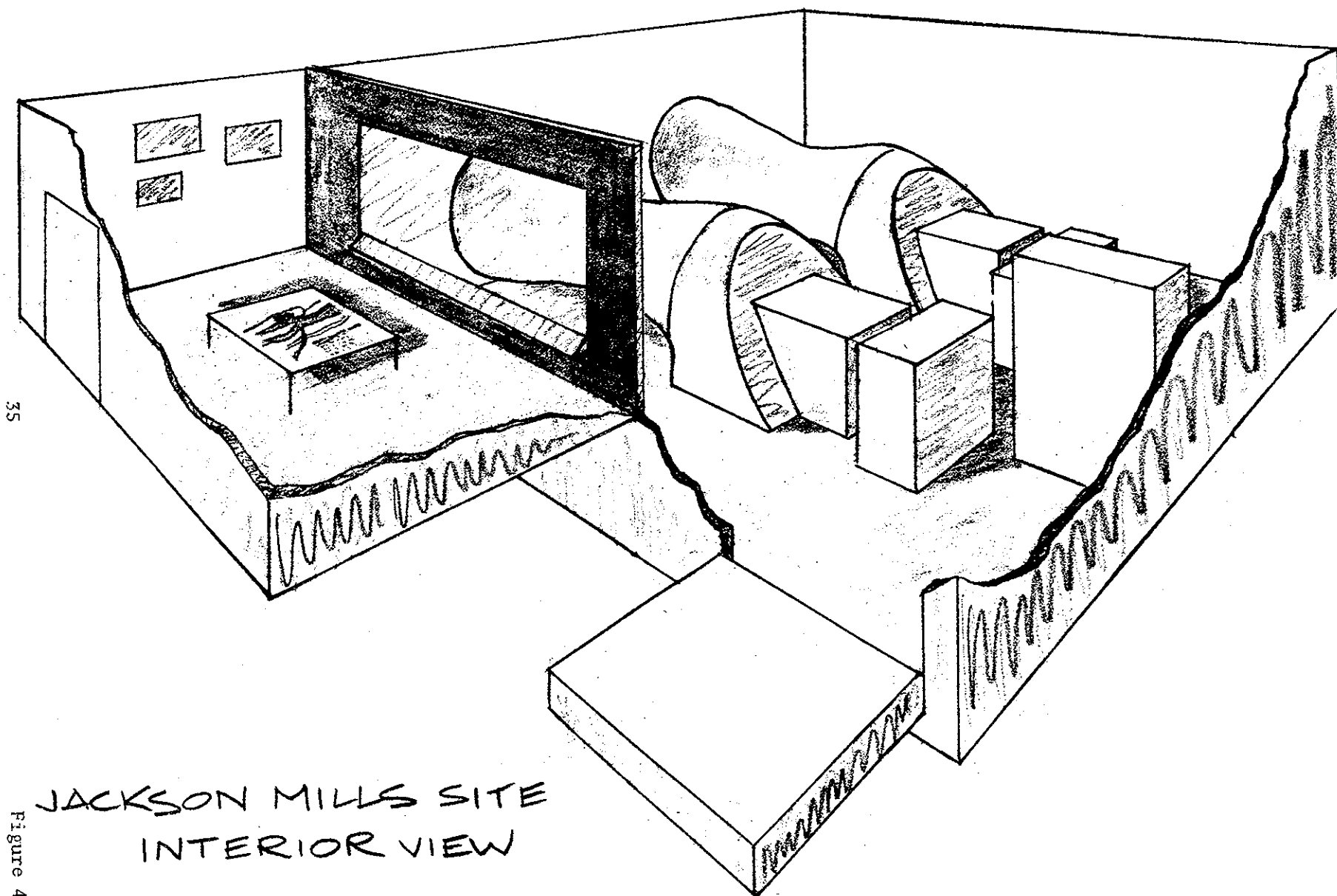


Figure 3

JACKSON MILLS SITE



35

JACKSON MILLS SITE
INTERIOR VIEW
Figure 4

FIRST YEAR **SECOND YEAR**
JULY AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUNE JULY AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUNE



project should be on line 24 months after start of construction.

11.4 Capital Costs

The capital cost for hydroelectric development at Jackson Mills Dam has been estimated to be \$1.98 million, and a breakdown appears in Table 7.

Turbine cost estimates were based on Volume V of the Corps of Engineers Hydrologic Engineering Center Guide Manual dated July 1979, adjusted from July 1978 price level to July 1979 and from conversations with regional representatives of Allis-Chalmers Corp.

TABLE 7

CAPITAL COSTS
JACKSON MILLS HYDROELECTRIC DEVELOPMENT

(\$ in 1000's)

Powerplant Structures and Improvements

Diversion and care of water	80
Excavation and foundation preparation	50
Substructure	235
Superstructure/Building	<u>185</u>
Subtotal	550

Reservoir, Dam and Waterway

Trash racks	40
Gates	40
Draft tube gates	20
Stoplogs	<u>10</u>
Subtotal	110

Generating Plant and Equipment

Turbine/generator package	1,000
Transmission and substation costs	<u>70</u>
Subtotal	1,070

TOTAL DIRECT COST 1,730

Engineering and Construction Supervision 250

TOTAL CAPITAL COST 1,980

12.0 FINANCIAL ANALYSIS

The financial scenario developed for hydroelectric generation at Jackson Mills Dam assumed that the City of Nashua would provide funding through 20-year bonds bearing an interest rate of 6%, serviced with a sinking fund established for the life of the bond issue.

The benefits are derived from the sale of the total power produced at the generating facility to the grid system. An order by the Public Utilities Commission of New Hampshire set a rate of 4¢/KWH to be paid for the output of run-of-river plants such as the proposed project at Jackson Mills. (Reference 9).

The costs include the capital cost of the plant and operation and maintenance which has been assumed to be two percent annually of the Total Direct Cost shown in Table 7.

Hydropower generating equipment typically has a service life of 50 years, providing that it is well maintained. The equipment selected for this study has been designed for standard application, a concept which has only been on the market for a few years. Therefore, a conservative life span of 40 years was assumed.

Since interest rates fluctuate, a sensitivity analysis was performed using interest rates of 4 percent, 6 percent, 8 percent and 10 percent. Table 8 presents a summary of the financial analysis of the various interest rates. The analysis compares present worth revenues (benefits) from the sale of power to present worth costs. The following pages show backup calculations and a cash flow with amortization of Capital Cost.

TABLE 8

PRESENT WORTH BENEFITS AND COSTS

Jackson Mills Site

Project Life: 40 years
 Initial Cost: \$1,980,000
 Energy: 5,450,000 KWH/yr
 Benefits: 4¢/KWH

	4%	6%	8%	10%
Present Worth Benefits	\$4,315,000	\$3,280,000	\$2,600,000	\$2,132,000
Present Worth Costs	\$2,665,000	\$2,501,000	\$2,393,000	\$2,318,000
Benefit/Cost Ratio	1.62	1.31	1.09	0.92

BENEFIT/COST ANALYSIS

Jackson Mills

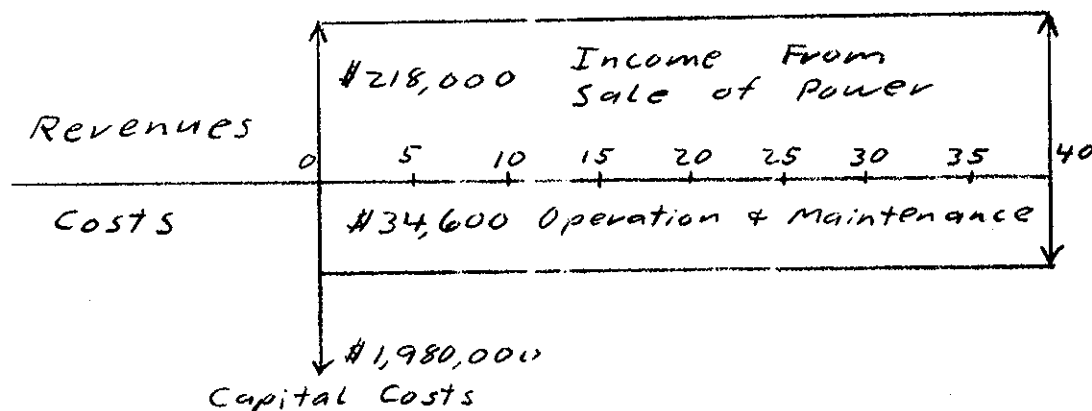
Project Life: 40 years

Initial Cost: \$1,980,000

Energy: 5,450,000 kWh/yr

Benefits: 4¢/kWh

Interest Rate: 4%



$$\begin{aligned} \text{Operation \& Maintenance} &= 2\% (\text{Total Direct Cost}) \\ &= .02 (\$1,730,000) \\ &= \$34,600 \end{aligned}$$

$$\begin{aligned} \text{Revenues} &= (5,450,000 \text{ kWh/yr}) (4¢/\text{kWh}) \\ &= \$218,000/\text{yr} \end{aligned}$$

$$\begin{aligned} \text{Present worth Benefits} &= \$218,000 (P/A)_{40}^{4\%} \\ &= \$218,000 (19.793) \\ &= \$4,314,874 \end{aligned}$$

$$\begin{aligned} \text{Present Worth Costs} &= \$1,980,000 + \$34,600 (P/A)_{40}^{4\%} \\ &= \$1,980,000 + \$684,838 \\ &= \$2,664,838 \end{aligned}$$

$$\text{Benefits/Costs} = \frac{\$4,314,874}{\$2,664,838} = \underline{\underline{1.62}}$$

BENEFIT / COST ANALYSIS

Jackson Mills

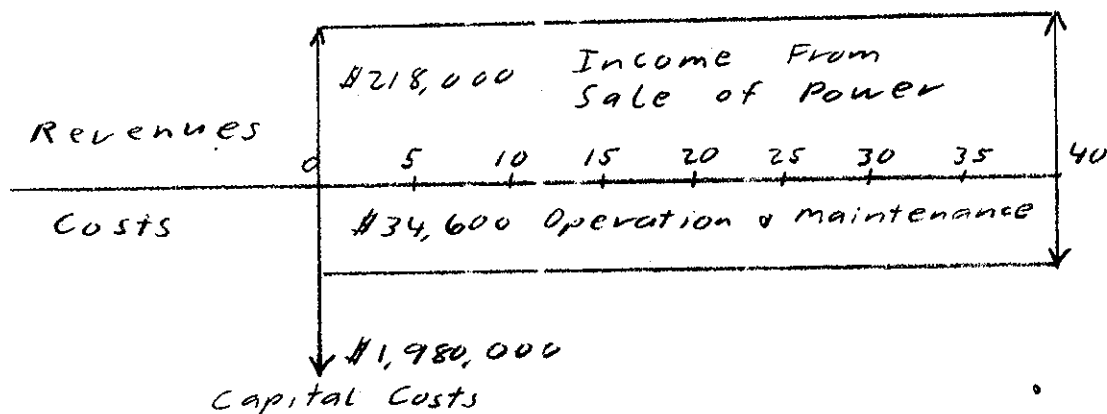
Project Life: 40 years

Initial Cost: \$1,980,000

Energy: 5,450,000 KWH/yr

Benefits: 4¢/KWH

Interest Rate: 6%



$$\begin{aligned} \text{Operation \& maintenance} &= 2\% (\text{Total Direct Cost}) \\ &= .02 (\$1,730,000) \\ &= \$34,600 \end{aligned}$$

$$\begin{aligned} \text{Revenues} &= (5,450,000 \text{ KWH/yr}) (4¢/\text{KWH}) \\ &= \$218,000/\text{yr} \end{aligned}$$

$$\begin{aligned} \text{Present Worth Benefits} &= \$218,000 (P/A)_{40}^{6\%} \\ &= \$218,000 (15.046) \\ &= \$3,280,028 \end{aligned}$$

$$\begin{aligned} \text{Present Worth Costs} &= \$1,980,000 + \$34,600 (P/A)_{40}^{6\%} \\ &= \$1,980,000 + \$520,592 \\ &= \$2,500,592 \end{aligned}$$

$$\text{Benefits/Costs} = \frac{\$3,280,028}{\$2,500,592} = \underline{\underline{1.31}}$$

BENEFIT/COST ANALYSIS

Jackson mills

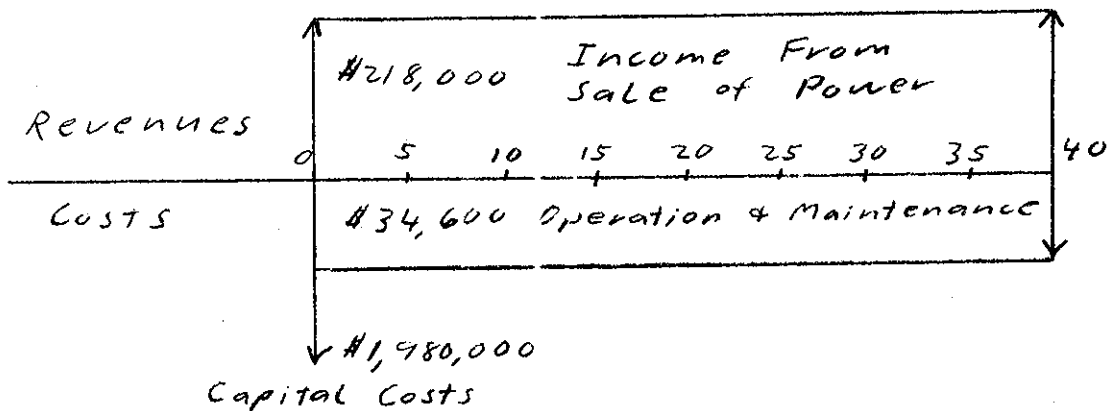
Project Life: 40 years

Initial Cost: \$1,980,000

Energy: 5,450,000 kWh/yr

Benefits: 4¢/kWh

Interest Rate: 8%



$$\begin{aligned} \text{Operation \& maintenance} &= 2\% (\text{Total Direct Cost}) \\ &= .02 (\$1,730,000) \\ &= \$34,600 \end{aligned}$$

$$\begin{aligned} \text{Revenues} &= (5,450,000 \text{ kWh/yr}) (4¢/\text{kWh}) \\ &= \$218,000/\text{yr} \end{aligned}$$

$$\begin{aligned} \text{Present worth Benefit:} &= \$218,000 (P/A)_{40}^{8\%} \\ &= \$218,000 (11.925) \\ &= \$2,599,650 \end{aligned}$$

$$\begin{aligned} \text{Present worth costs} &= \$1,980,000 + \$34,600 (P/A)_{40}^{8\%} \\ &= \$1,980,000 + \$412,605 \\ &= \$2,392,605 \end{aligned}$$

$$\text{Benefits/costs} = \frac{\$2,599,650}{\$2,392,605} = \underline{\underline{1.09}}$$

BENEFIT / COST ANALYSIS

Jackson Mills

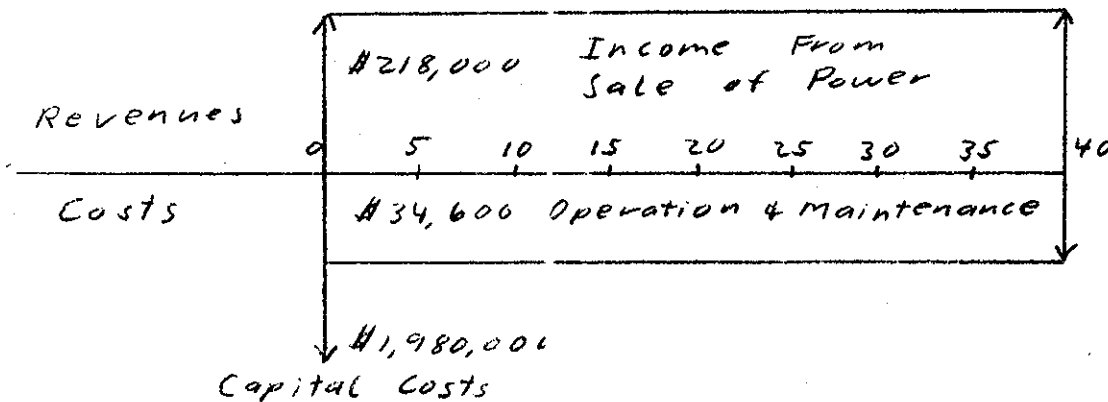
Project Life: 40 years

Initial Cost: \$1,980,000

Energy: 5,450,000 kWh/yr

Benefits: 4¢/kWh

Interest Rate: 10%



$$\begin{aligned}
 \text{Operation \& Maintenance} &= 2\% (\text{Total Direct Cost}) \\
 &= .02 (\$1,730,000) \\
 &= \$34,600
 \end{aligned}$$

$$\begin{aligned}
 \text{Revenues} &= (5,450,000 \text{ kWh/yr}) (4¢/\text{kWh}) \\
 &= \$218,000/\text{yr}
 \end{aligned}$$

$$\begin{aligned}
 \text{Present worth Benefits} &= \$218,000 (P/A)_{40}^{10\%} \\
 &= \$218,000 (9.779) \\
 &= \$2,131,822
 \end{aligned}$$

$$\begin{aligned}
 \text{Present worth costs} &= \$1,980,000 + \$34,600 (P/A)_{40}^{10\%} \\
 &= \$1,980,000 + \$338,353 \\
 &= \$2,318,353
 \end{aligned}$$

$$\text{Benefits / costs} = \frac{\$2,131,822}{\$2,318,353} = \underline{\underline{0.92}}$$

CASH FLOW WITH AMORTIZATION OF CAPITAL COST

Jackson Mills

Project Life: 40 years

Initial Cost: \$1,980,000

Energy: 5,450,000 kWh/yr

Benefits: 4¢/kWh

Interest Rate: 6%

20 Year Bond Life

YEARS 1-20

$$\text{Costs: Amortization} = \$1,980,000 (A/P)_{20}^{6\%}$$

$$= \$1,980,000 (.08718) = \$172,616$$

Operation & Maintenance

$$.02(\$1,730,000) = \$34,600$$

$$\text{Total Annual Cost} = \$207,216$$

Revenues:

$$(5,450,000 \text{ kWh/yr}) (4¢/\text{kWh}) = \$218,000$$

$$\text{Net Cash Flow} = \$10,784/\text{yr}$$

YEARS 21-40

Costs:

Operation & Maintenance

$$= .02(\$1,730,000) = \$34,600$$

Revenues:

$$(5,450,000 \text{ kWh/yr}) (4¢/\text{kWh}) = \$218,000$$

$$\text{Net Cash Flow} = \$183,400/\text{yr}$$

13.0 REGULATORY AND LICENSING CONSIDERATIONS

The proposed project is on the Nashua River which is currently classified as a navigable waterway. Thus, the project is under Federal Energy Regulatory Commission (FERC) jurisdiction as well as State jurisdiction. Since the project would have an installed capacity of less than 2000 HP (1500 KW), a short-form license application for a minor project with FERC can be employed. This license, a copy of which is presented in Appendix E, has incorporated a simplified procedure and format to save time and expense for the applicant.

The FERC license application requires that permits and approvals be obtained from numerous Federal, State and local authorities. At the Federal level, a dredge and fill permit must be obtained from the U.S. Army Corps of Engineers, and approval of the proposed project is necessary from the U.S. Environmental Protection Agency and the Fish and Wildlife Service of the U.S. Department of the Interior. Required at the State level are approval of the dam's safety by the Water Resources Board, a dredge and fill permit from the Special Board of the Water Resources Board, a State water quality certificate and a dredge and fill permit from the Water Supply and Pollution Control Commission, and approvals from the Fish and Game Department and the Office of Historic Preservation of the Department of Resources and Economic Development. Prior to construction, determination will have to be made if local building permits will have to be acquired.

If the environmental report section in the license application was unacceptable to a State or Federal agency, then an Environmental Impact Statement (EIS) may be required. In this case, a \$20,000 - \$100,000 expense and a minimum of a year project delay can be expected. Since the dam is existing and no major structural, hydraulic or pollution modeling or analysis is anticipated, an EIS for this project would be a lesser expenditure. FERC officials estimate the short-form licensing procedure, without the requirement of an EIS will take from 3 to 6 months for review by their agency after all State and other Federal approvals have been obtained.

Final approval and licensing of the Jackson Mills project will be based upon the assessment of the probable environmental impacts and the public needs including recreational, historical and archaeological. Consideration will be made of the project's impact on land use, water quality, fish and wildlife, recreation, historic and scenic value. Final approval will depend upon the applicant's ability to demonstrate that the proposed project will not endanger the safety, health or welfare of the general public or abutting landowners and will maintain the existing natural environmental conditions.

Presented in Appendix E are two flow diagrams designed to show the procedure to follow for successfully obtaining State approval and Federal licensing for the proposed project. The darker arrows in the flow diagram indicate the expected/desired path to be followed in this proposed project to obtain the necessary approvals and FERC licensing.

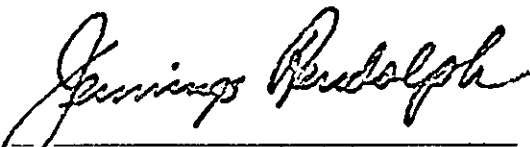
APPENDIX A - Significant Correspondence

United States Senate

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

COMMITTEE RESOLUTION

RESOLVED BY THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports of the Chief of Engineers on the Merrimack River, Massachusetts and New Hampshire, published as House Document Number 689, 75th Congress, 3rd Session, and other reports with a view to determining whether any modification of the recommendations contained therein is advisable at the present time, with particular reference to, but not limited to, hydroelectric power development of the Jackson Mills and Mines Falls Dam projects on the Nashua River, New Hampshire.



Jennings Randolph,

CHAIRMAN



Robert T. Stafford, RANKING MINORITY MEMBER

Adopted:December..6,..1978

GPO 88-717-2

(At the request of Senator John A. Durkin, New Hampshire)



STATE OF NEW HAMPSHIRE

Office of the Governor
2½ Beacon Street
Concord, NH 03301
603/271-2711
Toll Free 1-800-852-3466

Governor's Council on Energy

May 16, 1979

Mr. Joseph Ignazio
Chief, Planning Division
U.S. Army Corps of Engineers
424 Trapelo Rd.
Waltham, MA 02154

Re: Jackson Mills and Mines Falls Dams, Nashua, New Hampshire - (W15#14035)

Dear Mr. Ignazio:

I direct your attention to the following pertinent material concerning hydro feasibility in New Hampshire.

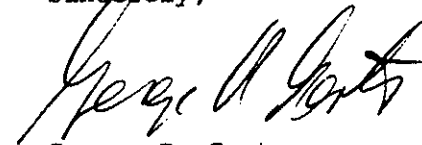
- Legal Obstacles and Incentives to the Development of Small Scale Hydroelectric Power in New Hampshire, by the Energy Law Institute, Franklin Pierce Law Center, Concord, N.H. for the US DOE, contract #ET-78-S-02-4934, 1979.
- Fundamental Economic Issues in the Development of Small Scale Hydro, same author and contract.
- Report of the New Hampshire PUC on DE-78-232 and DE 78-233 concerning Rates for Sale of Power by Limited Electrical Energy Producers.

This last document is very important, as it establishes the rate for small (under 5MW) power producers under a state law of 1978. Until the regulations under PURPA Title II (the National Energy Act of 1978) are promulgated and the PUC reviews this rate, small hydro producers selling all of their power to the utility will receive 4.5¢ per kwhr for firm capacity and 4.0¢ per kwhr for non-firm capacity.

A piece of legislation is being considered this year in New Hampshire which would also give small power producers the right to have power wheeled by a utility to an ultimate customer. The legislation is receiving a favorable response, and could have substantial implications for the two sites in Nashua.

I look forward to the Pre-Reconnaissance Report in June. If I can be of further assistance, please contact me.

Sincerely,



George R. Gantz
Director of Research
and
Policy Analysis

cc:
Mr. Alex Grier
Anderson-Nichols, Co.
150 Causeway St.
Boston, MA 02114

GRG/lb

Maurice L. Arel
Mayor



3/880-3341

July 6, 1979

Mr. Harman Guptill
Chief Hydroelectric Studies Branch
New England Division Corps. of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Guptill:

As requested in your meeting of June 25, 1979 with Tim Quinn and Dick Cane, this letter will confirm the City of Nashua's intention to acquire the Jackson Falls Dam, as well as the land along the south bank of the Nashua River. Negotiations with the landowners are currently underway and should be completed within the next several months.

I also wish to indicate support of your recommendation to construct the municipally owned and operated hydro facility along the south bank of the Nashua River in the vicinity of the Nashua Public Library. This location will offer a unique opportunity to develop related educational programs and facilities in conjunction with the library operations.

I appreciate the tremendous effort and support the Corps of Engineers has given to these projects and agree with your proposal to accelerate the Jackson Mills proposal. However, I also wish to reiterate my continued support for the Mine Falls Dam proposal and trust this project will continue to be studied and evaluated by the Corps as a part of the second phase of your efforts.

If I or my staff can be of any further assistance to you, please do not hesitate to call on us.

Sincerely,

Maurice L. Arel
Mayor

MLA/tjs



NEW HAMPSHIRE DEPARTMENT of RESOURCES and ECONOMIC DEVELOPMENT

GEORGE GILMAN
COMMISSIONER

TELEPHONE 603 271-2411

December 11, 1979

Joseph L. Ignazio
Chief, Planning Division
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Attention: Gard D. Blodgett

Dear Mr. Ignazio:

In accordance with 36 CFR 800, the New Hampshire State Historic Preservation Office has reviewed additional information provided by your staff, relating to the Jackson Mills Site in Nashua, New Hampshire.

It has been determined that no archaeological testing is required at the south abutment. As the proposed penstock will cut through the existing dam structure, it is suggested that the cross-section exposed by construction activities be documented as a precautionary measure, so that any previous construction on the site--if any--not reflected in the historical records, can be noted.

If these precautionary actions are taken, the project will not affect known architectural, historical and archaeological resources. Should other such resources be discovered as a result of project planning or implementation activities, appropriate surveys, determinations of National Register eligibility, redesign, protective, mitigative, or salvage measures should be undertaken in accord with Federal laws and regulations.

For the purpose of compliance with the Advisory Council on Historic Preservation Procedures (36 CFR 800), I request that this determination be construed as a finding of "no effect on architectural, historical and archaeological resources," and that it supersede the SHPO review letter to you, dated November 29, 1979.

Sincerely,

George Gilman, Commissioner
Dept. of Resources & Economic Development
NH State Historic Preservation Office

GG:g

cc: Sharon Conway, ACHP
Nashua Regional Plgn. Comm.
Gary W. Hume, SHPO Archaeologist



LISTING OF CONTACT/COORDINATION
DURING REPORT PREPARATION

AGENCY	INDIVIDUAL OR OFFICE CONTACTED	PURPOSE OF CONVERSATION/MEETING
Allis-Chalmers	John LaFlamme	Turbine units
Bofors-Nohab		Turbine units
City of Nashua	Mayor's office Tax Assessor Planning Board	Tax map data and planning information
Environmental Law Institute (Franklin Pierce Law Center, Concord, NH)	Peter Brown	Regulatory aspects of proposed projects
James River-Pepperell Company (East Pepperell, MA)	Edmond Roux	Operating procedures of hydropower unit and flow maintenance upstream on Nashua River
Nissho-Iwai American Corp.		Turbine units
Nissitissit River Trust	Jeffrey Smith	Nissitissit River hydrology
Public Service Company of New Hampshire	John Lyons	Sale of power
State of Massachusetts Water Pollution Control	Han Bonne	Flow Maintenance at James River-Pepperell Company
State of New Hampshire Dept. of Fish and Game	Stephen Virgin	Regulatory aspects
Dept. of Resources and Economic Development	Gary Hume Joseph Quinn Linda Wilson	Archaeological potential, regulatory aspects and historical significance relating to proposed project
Governor's Council on Energy	George Gantz William Humm	Regulatory aspects and marketing

Office of Secretary
of State

NH Legislation on
Small-Scale Hydro

Public Utilities
Commission

Bruce Ellsworth

Rate Information

Water Pollution
Council Commission

Walter Carlson
Donald Cheseborough

Nashua River water
quality & state
permits

Water Resources Board

Gary Kerr
Vernon Knowlton

Dam safety and state
permits from WRB

Sanders Associates

Thomas McNulty

Ownership of dam

Sulzer Brothers, Inc.

Turbine units

Tampella-Madden Corp.

Turbine units

United States
Federal Energy Regula-
tory Commission

Edward Abrams
Ronald Corso

Regulatory aspects
and licensing
requirements

Geological Survey

William McDonough
William Wandle

Nashua River
hydrology

APPENDIX B - Flow Duration Analysis

NASHUA RIVER HYDROLOGY

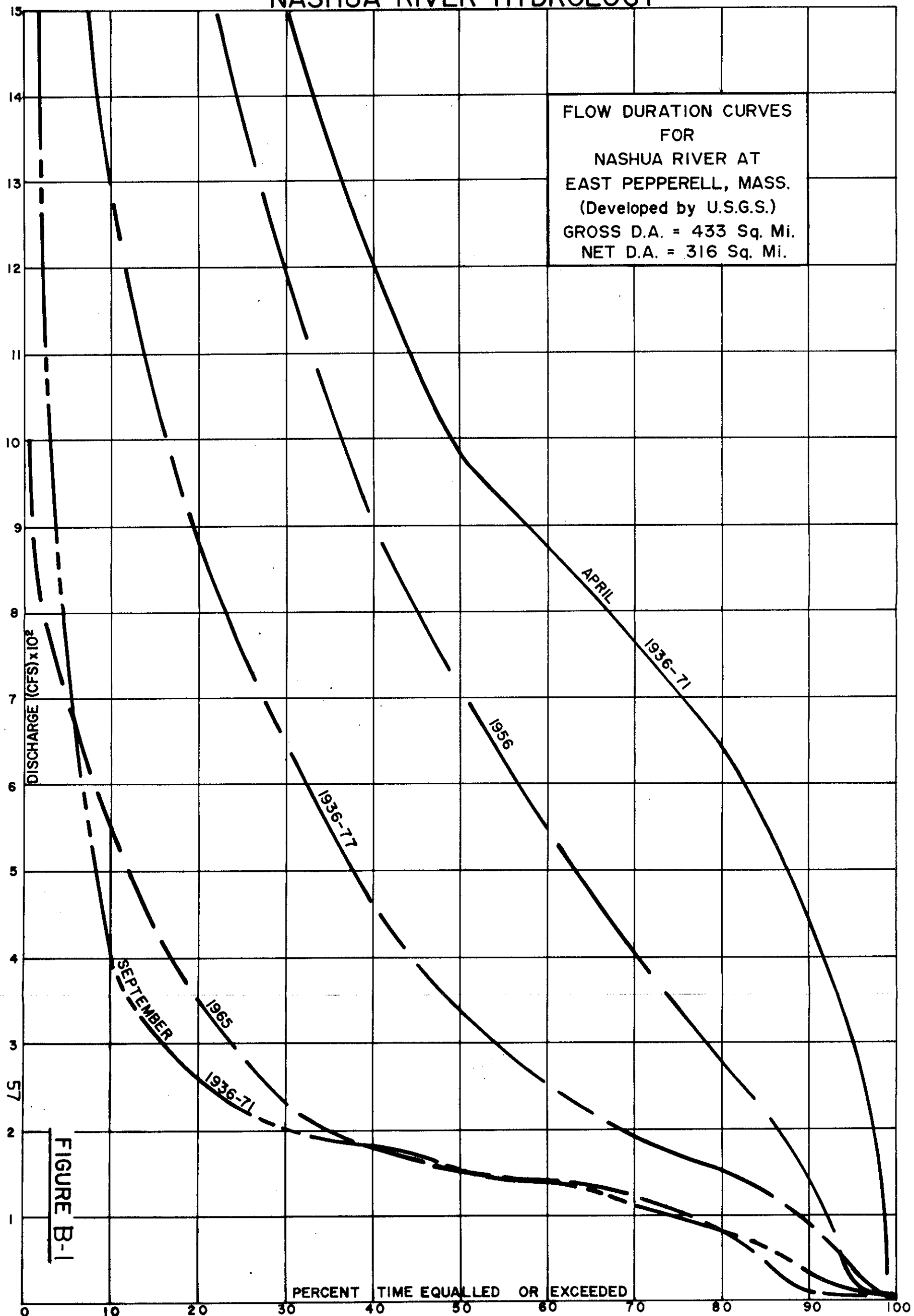
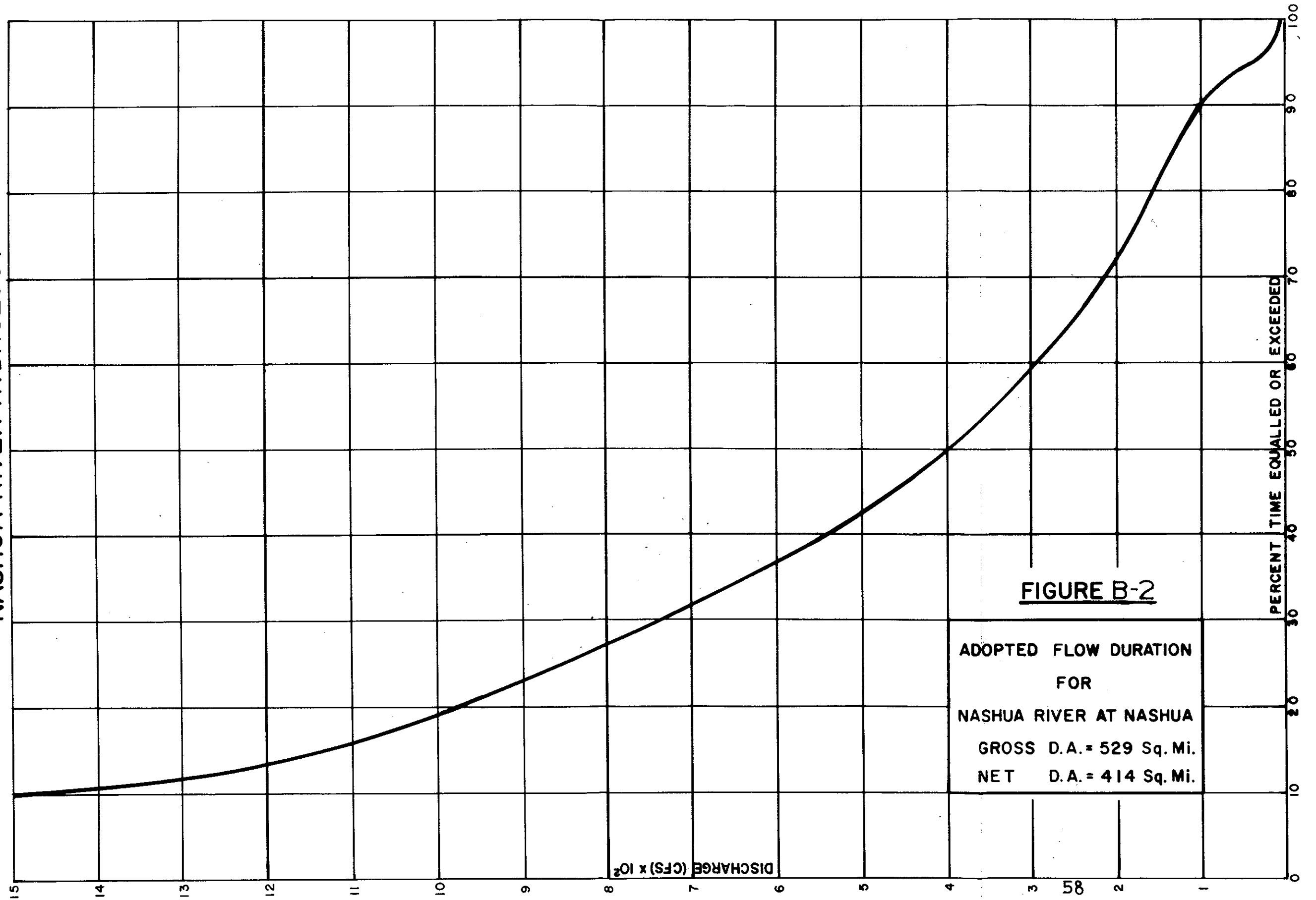
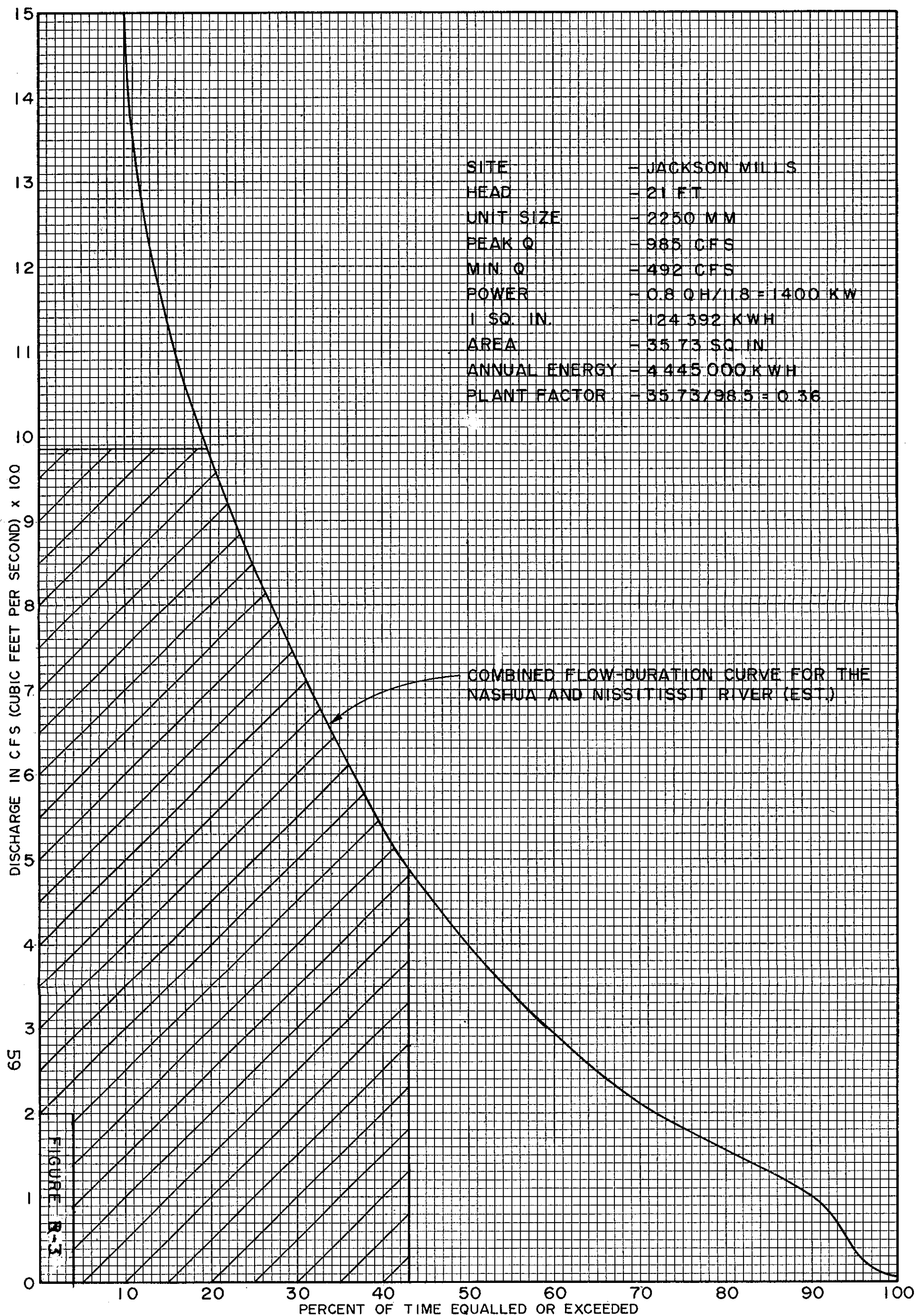
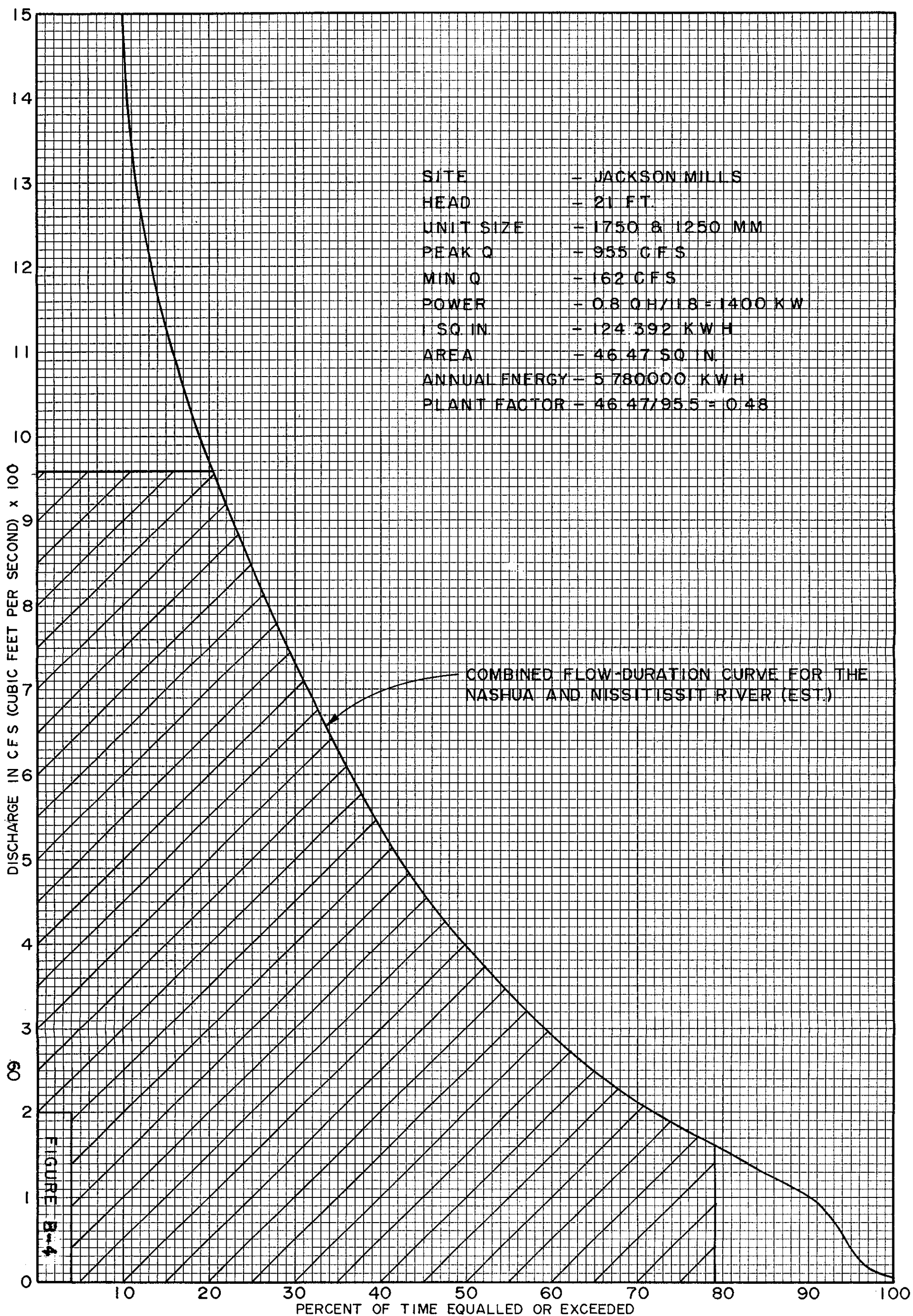


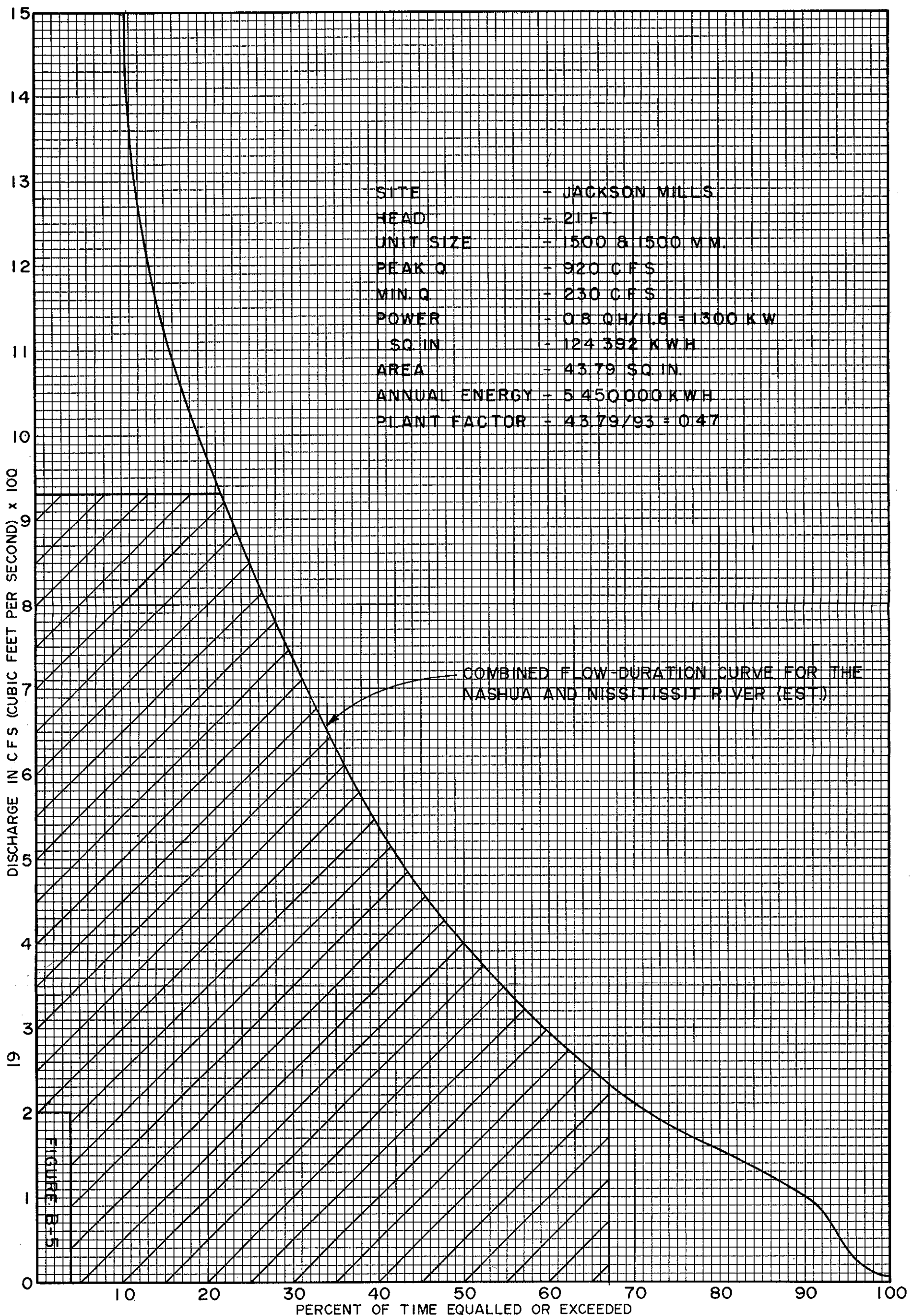
FIGURE B-1

NASHUA RIVER HYDROLOGY









APPENDIX C - Current NH Legislation
on Small-Scale Hydro

act in improving the availability and affordability of product liability insurance; shall review other existing laws and practices which bear on the availability and affordability of such insurance; and shall recommend such changes as may be necessary to increase availability and affordability of such insurance, while at the same time allowing just compensation to those suffering injury from products.

III. An interim report shall be prepared and submitted by the commission on April 1, 1979, to the governor, the president of the senate and the speaker of the house, with a final report due on or before January 1, 1980.

31:3 **Effective Date.** This act shall take effect 60 days after its passage.

[Approved June 23, 1978.]

[Effective date August 22, 1978.]

CHAPTER 32. (HB 35)

AN ACT RELATIVE TO PROVIDING EXEMPTIONS FROM PUBLIC UTILITY STATUS FOR CERTAIN ELECTRICAL ENERGY PRODUCERS AND SETTING RATES FOR SALE OF POWER GENERATED BY THOSE EXEMPTED PRODUCERS.

Be it Enacted by the Senate and House of Representatives in General Court convened:

32:1 **New Chapter.** Amend RSA by inserting after chapter 362 the following new chapter:

CHAPTER 362-A

LIMITED ELECTRICAL ENERGY PRODUCERS ACT

362-A:1 **Declaration of Purpose.** It is found to be in the public interest to provide for small scale and diversified sources of supplemental electrical power to lessen the state's dependence upon other sources which may, from time to time, be uncertain.

362-A:2 **Exemption of Limited Electrical Energy Producers.** Producers of electrical energy, not involving the use of nuclear or fossil fuels, with a developed output capacity of not more than 5 megawatts shall not be considered public utilities and shall be exempt from all rules, regulations and statutes applying to public utilities.

362-A:3 **Purchase of Output of Limited Electrical Energy Producers By Public Utilities.** The entire output of electric energy of such limited electrical energy producers, if offered for sale, shall be purchased by the electric public utility which serves the franchise area in which the installations of such producers are located.

362-A:4 **Payment by Public Utilities for Purchase of Output of Limited Electrical Energy Producers.** Public utilities purchasing electrical energy in accordance with the provisions of this chapter shall pay a

price per kilowatt hour to be set from time to time, by the public utilities commission.

362-A: 5 Settlement of Disputes. Any dispute arising under the provisions of this chapter may be referred by any party to the public utilities commission for adjudication.

32: 2 Effective Date. This act shall take effect 60 days after its passage.

[Approved June 23, 1978.]

[Effective date August 22, 1978.]

CHAPTER 33.

AN ACT CONCERNING THE ASSIGNMENT OF TEMPORARY JUSTICES OF THE SUPREME COURT.

Be it Enacted by the Senate and House of Representatives in General Court convened:

33:1 Justices. Amend RSA 490:1 by striking out said section and inserting in place thereof the following:

490:1 Justices. The supreme court shall consist of a chief justice and 4 associate justices, appointed and commissioned as prescribed by the constitution.

33:2 Temporary Justices. Amend RSA 490:3 by striking out said section and inserting in place thereof the following:

490:3 —Disqualification; Temporary Justices.

I. The provisions as to the disqualification of justices of the superior court apply to justices of the supreme court. Whenever a justice of the supreme court shall be disqualified or otherwise unable to sit in any cause or matter pending before such court, the chief or senior associate justice of the supreme court may assign another justice to sit according to the provisions of paragraph II of this section.

II. Upon the retirement, disqualification, or inability to sit of any justice of the supreme court, the chief justice or senior associate justice of the supreme court may assign a justice of the supreme court who has retired from regular active service to sit during supreme court sessions while the vacancy continues, or he may notify the chief justice or senior associate justice of the superior court of such vacancy. Upon such notification, the chief justice or senior associate justice of the superior court shall provide the supreme court for each day of sitting during a session while the vacancy shall continue with the names of 2 or more superior court justices in regular active service or who are retired and are not otherwise disqualified. The chief justice or senior associate justice of the supreme court may then assign a justice to sit temporarily on the court from among those superior court justices whose names have been provided.

III. A justice assigned to sit temporarily on the supreme court pursuant to paragraph II of this section shall have all the authority of a supreme court justice to hear arguments, render decisions, and file opinions. No

10 days after the receipt of said application. The applicants for such recount shall pay to the city clerk for the use of the city a fee of \$25. At the time appointed, the city council shall meet in convention and shall recount the ballots under such rules of procedures as they shall determine.

44:18 Declaration of Result. If, in case of a recount of such votes, it shall appear that the result of the voting on said question is other than that declared upon a canvass of the votes by the city council after a municipal election, the city council shall declare the result found by it upon such recount and such declaration shall be final unless the result is changed upon appeal to the superior court.

44:19 Applicability of Election Laws. Cities holding elections on days other than those of state elections shall be governed by the provisions of RSA 658 and 659 in the choice of city and ward officers in so far as such provisions are not inconsistent with city charter provisions or other state statutes.

410:25 Further Authority. If HB 575, An Act codifying the election laws, shall not become law, the director of legislative services is hereby authorized, with the approval of the speaker of the house and the president of the senate, to make changes in the numbering of the new chapters of the RSA inserted by this act and also the numbering of any RSA section cross references both in the new chapters and elsewhere in this act, provided that no substantive changes may thereby be made. Such authority shall expire upon the printing of the 1979 session laws.

410:26 Effective Date. This act shall take effect July 1, 1979.

(Approved June 23, 1979.)

(Effective Date July 1, 1979.)

CHAPTER 411 (HB 771) (Laws of 1979)

AN ACT RELATIVE TO THE SALE OF POWER BY LIMITED
ELECTRICAL ENERGY PRODUCERS.

Be it Enacted by the Senate and House of Representatives in General Court convened:

411:1 Contracting with Private Individuals. Amend RSA 362-A by inserting after section 2 the following new section:

362-A:2-a Purchase of Output by Private Sector.

I. A limited producer of electrical energy shall have the authority to sell its produced electrical energy to not more than 3 purchasers other than the franchise electric utility. Such purchaser may be any individual, partnership, corporation or association. The public utilities commission shall review and approve all contracts concerning a retail sale of electricity pursuant to this section. The public utilities commission shall not set the terms of such contracts but may disapprove any contract which in its judgement:

(a) Fails to protect both parties against excessive liability or undue risk, or

(b) Entails substantial cost or risk to the electric utility in whose franchise area the sale takes place, or

(c) Is inconsistent with the public good.

II. Upon request of a limited producer, any franchised electrical public utility in the transmission area shall transmit electrical energy from the producer's facility to the purchaser's facility in accordance with the provisions of this section. The producer shall compensate the transmitter for all costs incurred in wheeling and delivering the current to the purchaser. The public utilities commission must approve all such agreements for the wheeling of power and retains the right to order such wheeling and to set such terms for a wheeling agreement including price that it deems necessary. The public utilities commission or any party involved in a wheeling transaction may demand a full hearing before the commission for the review of any and all of the terms of a wheeling agreement.

III. Before ordering an electric utility to wheel power from a limited electric producer or before approving any agreement for the wheeling of power, the public utilities commission must find that such an order or agreement:

(a) is not likely to result in a reasonably ascertainable uncompensated loss for any party affected by the wheeling transaction.

(b) will not place an undue burden on any party affected by the wheeling transaction.

(c) will not unreasonably impair the reliability of the electric utility wheeling the power.

(d) will not impair the ability of the franchised electric utility wheeling the power to render adequate service to its customers.

411:2 Gross Sales. Amend RSA 362-A:3 (supp) as inserted by 1978, 32:1 by striking out said section and inserting in place thereof the following:

362-A:3 Purchase of Output of Limited Electrical Energy Producers by Public Utilities. The entire output of electric energy of such limited electrical energy producers, if offered for sale to the electric utility, shall be purchased by the electric public utility which serves the franchise area in which the installations of such producers are located. No electric public utility shall be required to purchase the entire output of electric energy if the amount of the purchase exceeds 10 percent of the utility's gross sales of electricity.

411:3 Effective Date. This act shall take effect 60 days after its passage.

(Approved June 23, 1979.)

(Effective Date August 22, 1979.)

NEW HAMPSHIRE

1978 SPECIAL SESSION

House Bill No. 35 was passed by the Legislature and became Chapter 32 of the Laws of 1978, Special Session. Chapter 32 inserted CHAPTER 362-A in the New Hampshire Revised Statutes Annotated.

1979 REGULAR SESSION

House Bill No. 771 was passed by the Legislature and became Chapter 411 of the Laws of 1979. This inserted a new section in RSA 362-A: 362-A:2-a; and amended 362-A:3; so that section 362-A:3 should now read as amended by Chapter 411 of the Laws of 1979.

(When the 1979 SUPPLEMENTS to the Revised Statutes Annotated are printed, Chapter 362-A will be as amended by the 1979 Legislature.)

APPENDIX D - NH Public Utilities Commission
Report on Rates

CHAIRMAN
MICHAEL LOVE
COMMISSIONERS
FRANCIS J. RIORDAN
ALCOLM J. STEVENSON



VINCENT J. IACOPINO
SECRETARY

DE 78-232
DE 78-233

State of New Hampshire
PUBLIC UTILITIES COMMISSION
Concord 03301
Telephone Area Code 603
271-2452

PRESS RELEASE
April 19, 1979

The New Hampshire Public Utilities Commission issued its report today establishing a price to be paid by electric utilities for purchase of energy from limited electrical energy producers, such as operators of small hydro-electric plants. A price of 4.5¢ per kilowatt-hour is established for energy from plants which produce such energy on a dependable capacity basis, while 4.0¢ per kilowatt-hour is set for energy from those plants which produce such energy on a non-dependable capacity basis (such as run-of-the-river hydro plants).

In its decision, the Commission stated that it was guided by the intent of legislation recently passed by the New Hampshire Legislature and the United States Congress, both of which call for the development of small-scale and diversified sources of supplemental electric power, and the conservation of fossil fuels.

The Commission pointed out that Federal rules have not as yet been promulgated to fully implement the Federal legislation, but at the time such rules become available the Commission will re-evaluate its present decision.

The Commission also indicated that annual adjustments of the prices set will be in order.

NEW HAMPSHIRE ELECTRIC COOPERATIVE, INC.

DE 78-233

PUBLIC SERVICE COMPANY OF NEW HAMPSHIRE

Rate for Sale of Energy by Limited Electrical Energy Producers

..00..

ORDER NO. 13,589

Upon consideration of the foregoing Report, which is made a part hereof; it is

ORDERED, that pursuant to the provisions of PURPA and RSA 362-A:4, public electric utilities purchasing electrical energy from Limited Electric Energy Producers operating plants in the utility's franchise area, not involving the use of nuclear or fossil fuels, with a developed output capacity of not more than five (5) Megawatts, shall pay for the entire output of electric energy, if offered for sale, a price for the next twelve (12) months for all energy purchased on and after May 1, 1979, as follows:

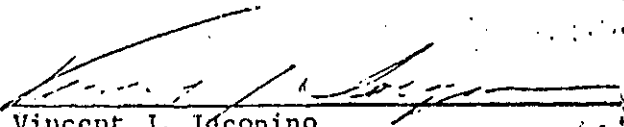
- A. From plants which produce energy on a non-dependable capacity basis (such as run-of-the-river hydro plants) - Four (4) cents per kilowatt-hour (KWH);
- B. From plants which produce energy on a dependable capacity - Four and one-half (4.5) cents per kilowatt-hour (KWH);

and it is

FURTHER ORDERED, that the Commission will re-examine the PURPA issues in this proceeding upon the issuance of rules by the FERC; and it is

FURTHER ORDERED, that it is the intent of this Commission that subsequent annual adjustments will be made.

By order of the Public Utilities Commission of New Hampshire this eighteenth day of April 1979.


Vincent J. Iacopino
Executive Director and Secretary

APPENDIX E - Regulatory and Licensing

Docket No. RM78-9

APPLICATION FOR SHORT-FORM LICENSE (MINOR)

1. Applicant's full name and address: _____

(Zip Code)

2. Location of Project:
State: _____ County: _____
Nearest town: _____ Water body: _____

3. Project description and proposed mode of operation
(reference to Exhibits K and L, as appropriate):

(continue on separate sheet, if necessary)

4. Lands of the United States affected (shown on Exhibit K)
(Name) (Acres)

- a. National Forest _____
b. Indian Reservation _____
c. Public Lands Under
Jurisdiction of _____
d. Other _____
e. Total U.S. Lands _____
f. Check appropriate box:

☒ Surveyed ☐ Unsurveyed land in public-land
state:

(1) If surveyed land in public-land state provide the
following:

Sections and subdivisions: _____
Range _____ Township: _____
Principal base and meridian: _____

(2) If unsurveyed or not in public-land state, see
Item 8 of instructions: _____

5. Purposes of project (use of power output, etc.)

Docket No. RM78-9

6. Construction of the project is planned to start _____
it will be completed within _____ months from the date of
issuance of license.
7. List here and attach copies of State water permits or other
permits obtained authorizing the use or diversion of water,
or authorizing (check appropriate box):
☐ the construction, operation, and maintenance
☐ the operation and maintenance
of the proposed project.
8. Attach an environmental report prepared in accordance
with the requirements set forth in the Instructions for
Completing Application for Short-Form License (Minor),
below.
9. Attach Exhibits K and L drawings.
10. State of _____
County of _____ ss:

being duly sworn, depose(s) and say(s) that the contents of
this application are true to the best of _____ knowledge or
belief and that (check appropriate box)

☐ _____ is (are) a citizen(s) of the United States

☐ all members of the association are citizens of the
United States

☐ _____ is (are) the duly appointed agent(s) of the
state (municipality) (corporation) (**association**)

and has (have) signed this application this _____ day of _____,
19____.

(Applicant(s))

Docket No. RM78-9

By _____
Subscribed and sworn to before me, a Notary Public of the
State of _____, this ____ day of _____,

/SEAL/

(Notary Public)

INSTRUCTIONS FOR COMPLETING APPLICATION
FOR SHORT-FORM LICENSE (MINOR)

GENERAL

1. This application may be used if the proposed or existing project will have or has a total generating capacity of not more than 1,500 kW (2,000 horsepower). Advice regarding the proper procedure for filing should be requested from the Federal Energy Regulatory Commission in Washington, D. C.; or from one of the Commission's Regional Offices in Atlanta, Chicago, Fort Worth, New York, or San Francisco.

2. This application is to be completed and filed in an original and nine copies with the Federal Energy Regulatory Commission, 825 N. Capitol Street, N.E., Washington, D. C. 20426. Each of the original and the nine copies of the application is to be accompanied by:

- a. One copy each of Exhibits K and L described below.
- b. One copy each of a state water quality certificate pursuant to Section 401 of the Federal Water Pollution Control Act (or evidence that this certificate is not needed), and any water rights certificate or similar evidence required by state law relating to use or diversion of water. In lieu of submitting a copy of a Section 401 certificate (or other certificate), evidence that applications for these certificates have been filed with appropriate agencies, or that such certificates are not necessary, will be adequate to begin FERC processing of the application.
- c. One copy each of any other state approvals necessary. (Applicant should contact the state natural resources department or equivalent to ascertain whether any such approvals are necessary.)

Docket No. RM78-9

- d. One copy of Applicant's environmental report, described below.

3. Applicant is required to consult with appropriate Federal, State, and local resources agencies during the preparation of the application and provide interested agencies with the opportunity to comment on the proposal prior to its filing with the Commission. The comments of such agencies must be attached to the application when filed. A list of agencies to be consulted can be obtained from the Commission's main office or the appropriate regional office.

4. No work may be started on the project until receipt of a signed license from the Commission. The application itself does not authorize entry upon Federal land for any purpose. If the project is located in part or in whole upon Federal land, the Applicant should contact the appropriate land management agency regarding the need to obtain a right-of-way permit. As noted above, other state or Federal permits may be required.

5. An applicant must be: a citizen or association of citizens of the United States; a corporation organized under the laws of the United States or a State; a State; or a municipality.

- (a) If the applicant is a natural person, include an affidavit of United States citizenship.
- (b) If the applicant is an association, include one verified copy of its articles of association. If there are no articles of association, that fact shall be stated over the signature of each member of the association. Also include a complete list of members and a statement of the citizenship of each in an affidavit by one of them.

Docket No. RM78-9

- (c) If the applicant is a corporation, include one copy of the charter or certificate and articles of incorporation, with all the amendments, duly certified by the secretary of state of the State where organized, and one copy of the by-laws. If the project is located in a state other than that in which the corporation is organized, include a certificate from the secretary of state of the State in which the project is located showing compliance with the laws relating to foreign corporations.
- (d) If the applicant is a state, include a copy of the laws under the authority of which the application is made.
- (e) If the applicant is a municipality as defined in the Federal Power Act, include one copy of its charter or other organization papers, duly certified by the secretary of state of the State in which it is located, or other proper authority. Also include a copy of the State laws authorizing the operations contemplated by the application.

Include a copy of all minutes, resolutions of stockholders or directors, or other representatives of the applicant, properly attested, authorizing the filing of the application. This information can be provided by a letter attached to the application.

6. If the stream or water body is unnamed, give the name of the nearest named stream or water body to which it is tributary.

Docket No. RM78-9

7. The project description (application item 3) shall include, as appropriate: the number of generating units, including auxiliary units, the capacity of each unit, and provisions, if any, for future units; type of hydraulic turbine(s); a description of how the plant is to be operated, manual or automatic, and whether the plant is to be used for peaking; estimated average annual generation in kilowatt-hours or mechanical energy equivalent; estimated average head on the plant; reservoir surface area in acres and, if known, the net and gross storage capacity; estimated hydraulic capacity of the plant (flow through the plant) in cubic feet per second; estimated average flow of the stream or water body at the plant or point of diversion; sizes, capacities, and construction materials, as appropriate, of pipelines, ditches, flumes, canals, intake facilities, powerhouses, dams, transmission lines, etc.; and estimated cost of the project.

8. In the case of unsurveyed public land, or land not in a public-lands state, give the best legal description available. Include the distance and general direction from the nearest city or town, fixed monument, physical features, etc.

9. Exhibits K and L shall be submitted on separate drawings. Drawings for Exhibits K and L shall have identifying title blocks and bear the following certification: "This drawing is a part of the application for license made by the undersigned this ____ day of _____, 19____.

(Name of Applicant)

Docket No. RM78-9

10. The Commission reserves the right to require additional information, or another filing procedure, if data provided indicate such action to be appropriate.

EXHIBIT K-PROJECT LANDS AND BOUNDARIES

1. The Exhibit K is a planimetric map showing the portion of the stream developed, the location of all project works, and other important features, such as: the dam or diversion structure, reservoir pipeline, powerplant, access roads, transmission lines, project boundary, private land ownerships (clearly differentiate between fee ownership and land over which applicant only owns an easement), and Federal land boundaries and identifications.

2. The map shall be an ink drawing or drawing of similar quality on a sheet not smaller than 8 inches by 10-1/2 inches, drawn to a scale no smaller than one inch equals 1,000 feet. Ten legible prints shall be submitted with the application. Upon request after review of the application, the tracing must be submitted.

3. The project boundary shall be drawn on the map so that the relationship of each project facility and reservoir to other property lines can be determined. The boundary shall enclose all project works, such as the dam, reservoir, pipelines, roads, powerhouse, and transmission lines. The boundary shall be set at the minimum feasible distance from project works necessary to allow operation and maintenance of the project and control of the shoreline and reservoir. The distance in feet from each principle facility to the boundary shall be shown. The project boundary should be a surveyed line with stated courses and distances. A tape-compass survey is acceptable. True north shall be indicated on the map.

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The area of Federal land in acres within the project boundary shall be shown. The appropriate Federal agency should be contacted for assistance in determining the Federal land acreage. For clarity, use inset sketches to a larger scale than that used for the overall map to show relationships of project works, natural features, and property lines.

4. Show one or more ties by distance and bearing from a definite, identifiable point or points on project works or the project boundary to established corners of the public land survey or other survey monuments, if available.

5. If the project affects unsurveyed Federal lands, the protraction of township and section lines shall be shown. Such protractions, whenever available, shall be those recognized by the agency of the United States having jurisdiction over the lands. On unsurveyed lands, show ties by distance and bearing to fixed recognizable objects.

6. If the project uses both Federal and private lands, the detailed survey descriptions discussed above for the project boundary apply only to Federal lands. General location data and an approximate project boundary will normally suffice for project works on private lands.

EXHIBIT L-PROJECT STRUCTURES AND EQUIPMENT

1. The exhibit shall be a simple ink drawing or drawing of similar quality on a sheet no smaller than 8 inches by 10-1/2 inches, drawn to a scale no smaller than one inch equals 50 feet for plans and profiles, and one inch equals 10 feet for sections. Ten legible prints shall be submitted with the application. Upon request after initial review of the application, tracings must be submitted.

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2. The drawing shall show a plan, elevation, and section of the diversion structure and powerplant. Generating and auxiliary equipment proposed should be clearly and simply depicted and described. Include a north arrow on the plan view.

ENVIRONMENTAL REPORT

The environmental report should be consistent with the scope of the project and the environmental impacts of the proposed action; e.g., authorization to operate and maintain an existing project, or a project using an existing dam or other facility, would require less detailed information than authorization to construct a new project. The environmental report shall set forth in a clear and concise manner:

- (1) A brief description of the project and the mode of operation, i.e., run-of-river, peaking or other specific mode.
- (2) A description of the environmental setting in and near the project area, to include vegetative cover, fish and wildlife resources, water quality and quantity, land and water uses, recreational use, socio-economic aspects, historical and archeological resources, and visual resources. Special attention shall be provided endangered and threatened plant and animal species, critical habitats, and sites eligible for or included on the National Register of Historic Places. Assistance in the preparation of this information may be obtained from state natural resources departments and from local offices of Federal natural resources agencies.

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- (3) A description of the expected environmental impacts resulting from the continued operation of an existing project, or from the construction and operation of a new project or a project using an existing dam or other existing facility. Include a discussion of specific measures proposed by the Applicant and others to protect and enhance environmental resources and to mitigate adverse impacts of the project on the environmental resources and values, the cost of those measures, and the party undertaking to implement those measures if other than the Applicant.
- (4) A description of alternative means of obtaining an amount of power equivalent to that provided by the project in the event that construction or continued operation of the project is not authorized.
- (5) A description of the steps taken by the Applicant in consulting with Federal, state, and local agencies during the preparation of the environmental report. Indicate which agencies have received the final report and provide copies of letters containing the comments of those agencies.

REGULATION OF SMALL DAMS IN NEW HAMPSHIRE (I.)
as applies to
FEASIBILITY OF MINE FALLS DAM AND JACKSON MILLS DAM

(I.) Excerpted from "Legal Obstacles and Incentives to the Development of Small Scale Hydroelectric Power in New Hampshire", by the Energy Law Institute, Franklin Pierce Law Center, Concord, New Hampshire.

Anderson-Nichols & Company, Inc. is solely responsible for its interpretation as presented herein.

HYDROELECTRIC PROJECT

OWNERSHIP

- does the developer have the legal right to use of the flowing water?
- does the developer own both banks?
- is the water navigable, public or non-navigable?

See Flow Diagram for Federal Regulations

Apply to state legislature for legislative charter conferring the use and enjoyment of the water course to the developer.
-Public Trust Doctrine

Denied

Approved

Apply: for major dam construction permit with Water Resources Board

If developer is private entity or municipality

File statement with Water Resources Board

Water Resources Board determines if dam will be a menace to public safety if improperly constructed

NO

YES

File plans and specifications with Water Resources Board

Determine: effect on other interests and apply for necessary permits with appropriate agencies

- dredge and fill and state water quality certificate from Water Supply and Pollution Control Commission
- dredge and fill in wetlands from Water Resources Board (Special Board)
- Department of Fish & Game determination of need for fishladder(s)

Approved

Denied

Successful

Appeal to State Court

Will the dam generate in excess of 5 megawatts or be a municipal corporation operating outside the corporate limits?

NO

Dam is not a public utility

Construction, operation and maintenance of dam.
-comply with conditions of all permits
-utilize Mill Act

File Petition with Water Resources Board. Water Resources Board holds hearing

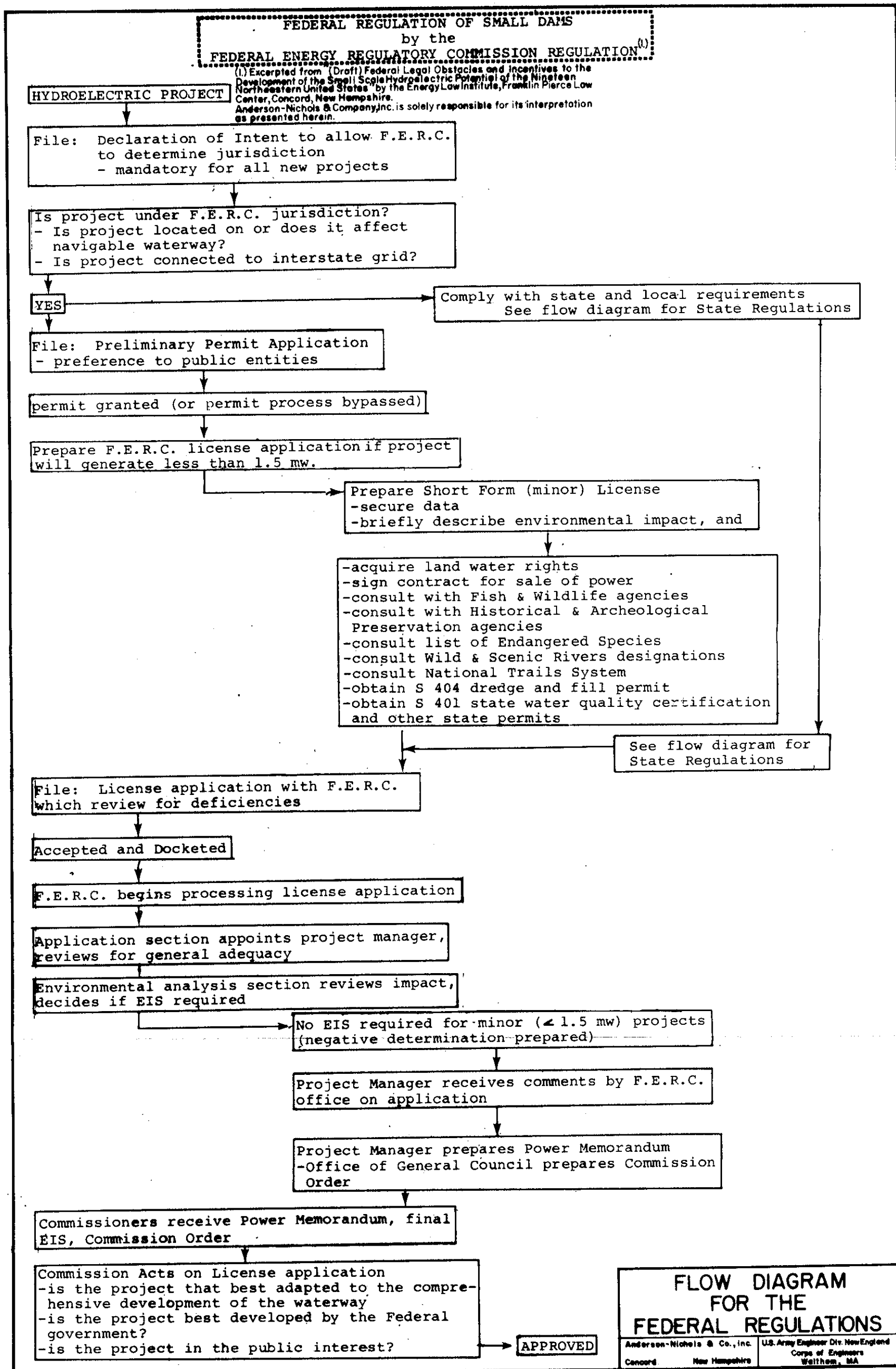
Denied

Approved

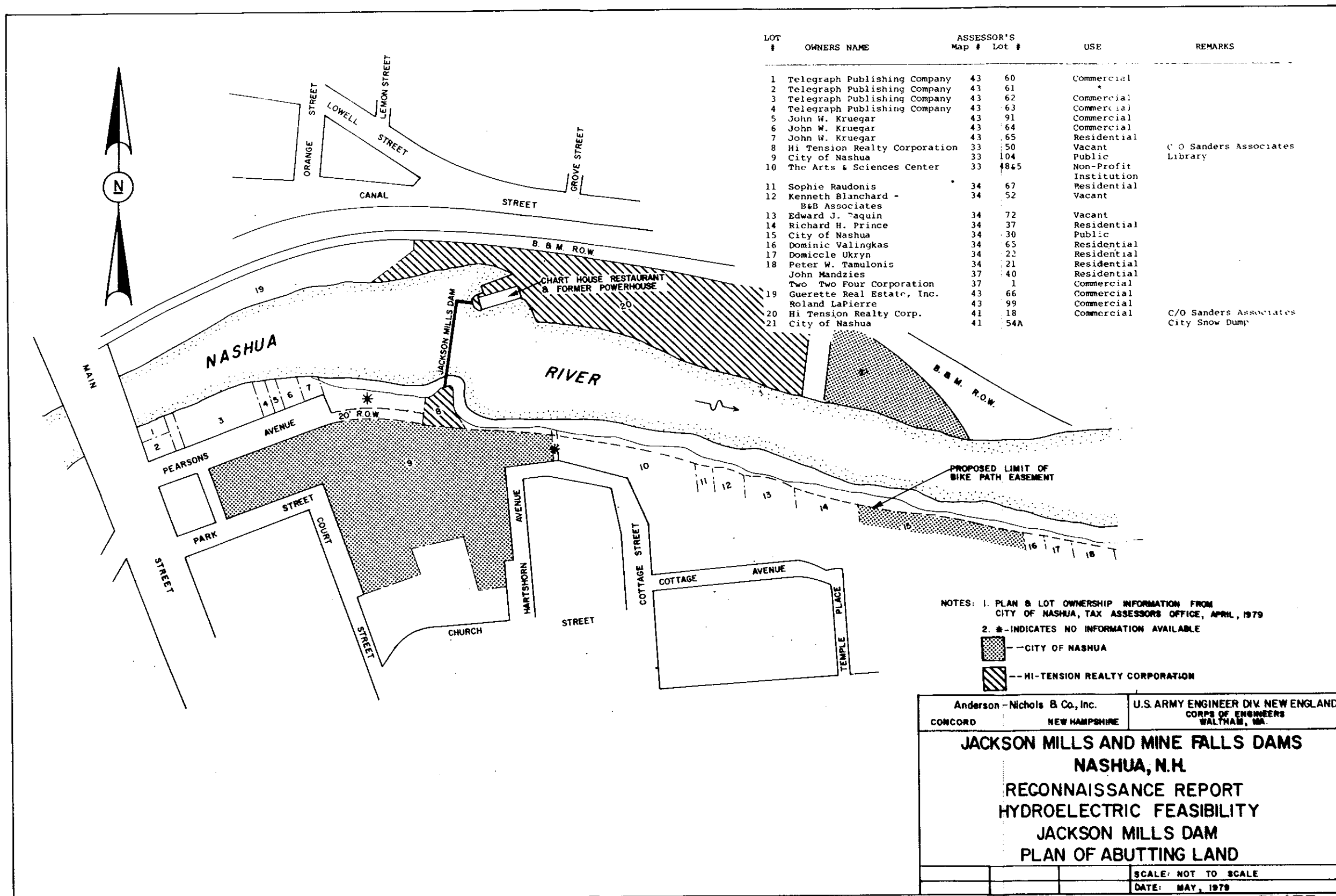
See Flow Diagram for Federal Regulations

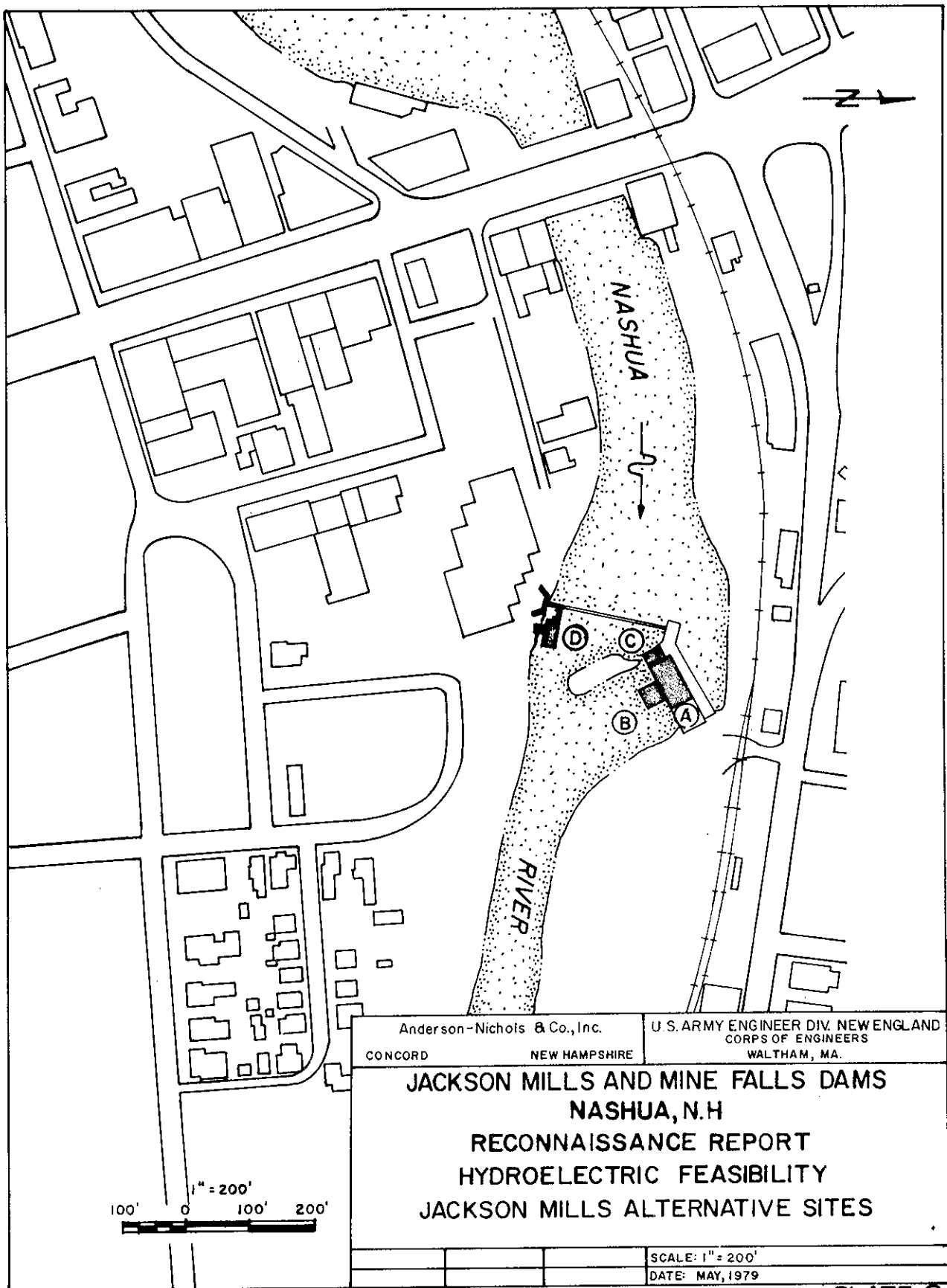
**FLOW DIAGRAM
FOR THE
STATE REGULATIONS**

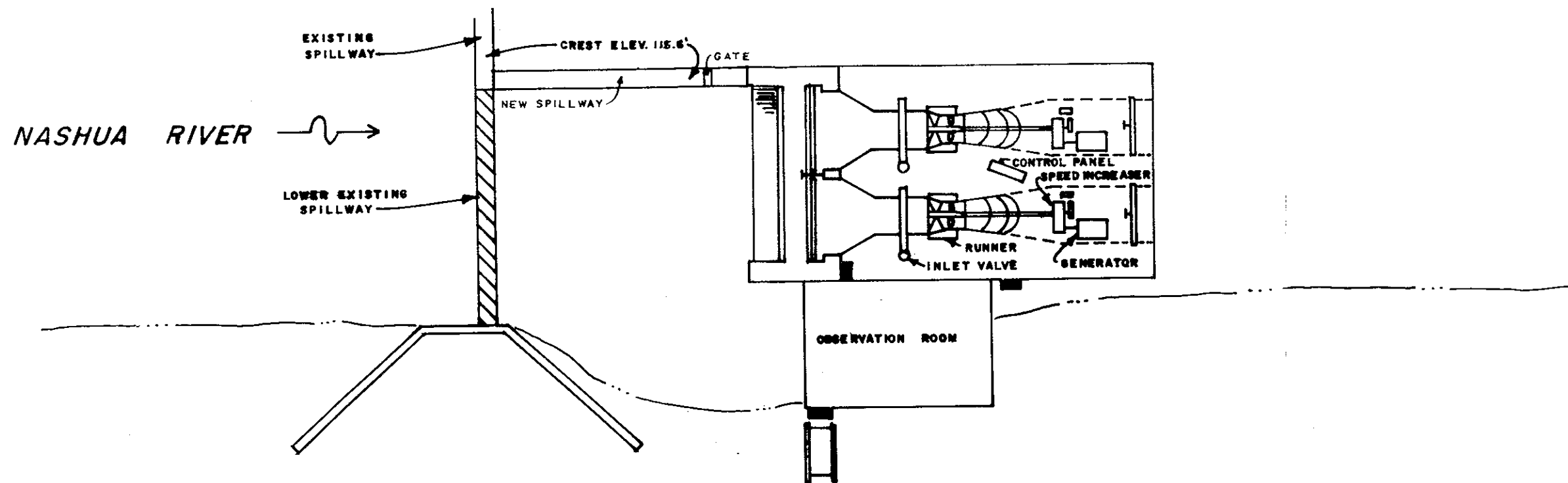
Anderson-Nichols & Co., Inc. U.S. Army Engineer Div. New England
Concord New Hampshire Corps of Engineers
Waltham, MA



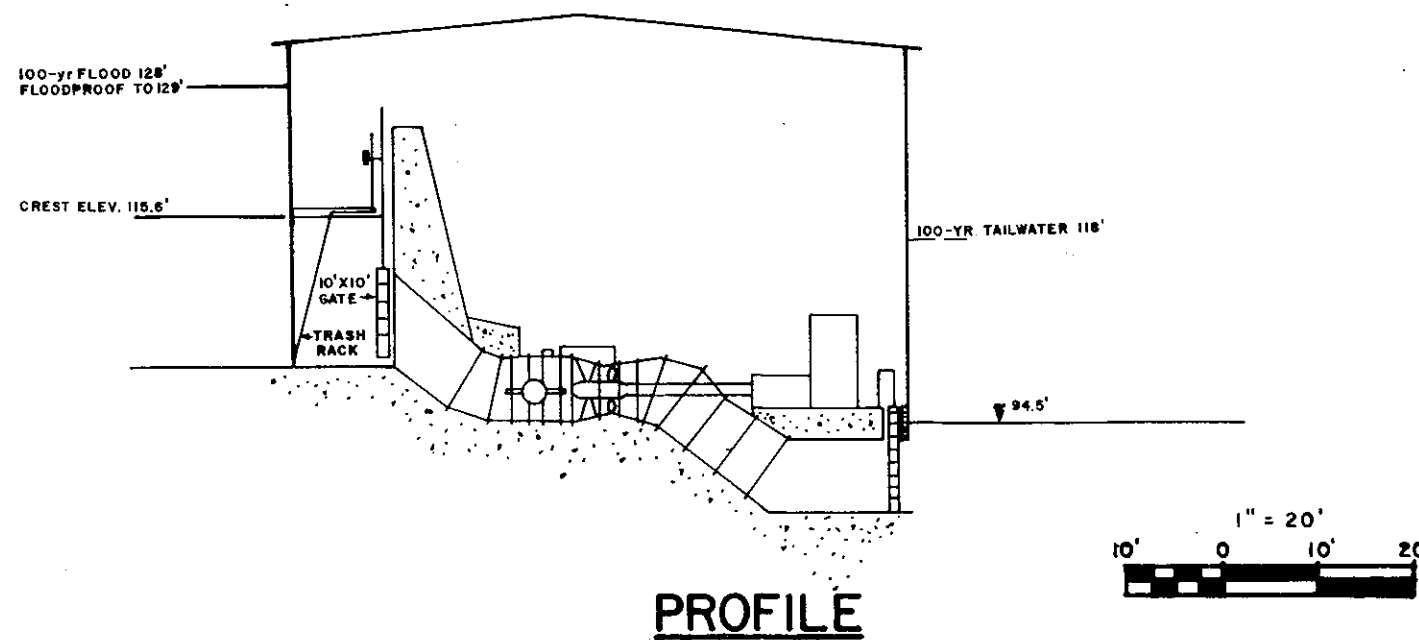
APPENDIX F - Plates







PLAN



Anderson-Nichols & Co., Inc. CONCORD NEW HAMPSHIRE	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA.
JACKSON MILLS AND MINE FALLS DAMS NASHUA, N.H. RECONNAISSANCE REPORT HYDROELECTRIC FEASIBILITY JACKSON MILLS SITE	
SCALE: 1" = 20'	
DATE: MAY, 1979	

DEFINITIONS AND TERMS

CAPACITY - The maximum power output or load for which a turbine-generator, station or system is rated.

DEPENDABLE CAPACITY - The load carrying ability of a hydropower plant under adverse hydrologic conditions for the time interval and period specified of a particular system load.

DRAWDOWN - The distance that the water surface elevation of a storage reservoir is lowered from a given or starting elevation as a result of the withdrawal of water to meet some project purpose (i.e., power generation, creating flood control space, irrigation demand, etc.).

ENERGY - The capacity for performing work. The electrical energy term generally used is kilowatt-hours and represents power (kilowatts) operating for some time period (hours).

FEDERAL ENERGY REGULATORY COMMISSION (FERC) - An agency in the Department of Energy which licenses non-Federal hydropower projects and regulates interstate transfer of electric energy. Formerly the Federal Power Commission (FPC).

FIRM ENERGY - The energy generation ability of a hydropower plant under adverse hydrologic conditions for the time interval and period specified of a particular system load.

FOREBAY - The impoundment immediately above a dam or hydroelectric plant intake structure. The term is applicable to all types of hydroelectric developments (i.e., storage, run-of-river and pumped-storage).

GENERATOR - A machine which converts mechanical energy into electric energy.

GROSS HEAD - The difference in water surface elevation as measured in the forebay and tailrace of a hydropower plant, under certain specified conditions. Usually, gross head refers to the difference between normal full pool and average tailwater elevations.

HYDROELECTRIC PLANT or HYDROPOWER PLANT - An electric power plant in which the turbine/generators are driven by falling water.

INSTALLED CAPACITY - The total of the capacities shown on the nameplates of the generating units in a hydropower plant.

KILOWATT (Kw) - One thousand watts.

KILOWATT-HOUR (Kwh) - The amount of electrical energy involved with a one-kilowatt demand over a period of one hour. It is equivalent to 3,413 Btu of heat energy.

LICENSE APPLICATION - The FERC issues two types of licenses: one for projects of less than 1.5 Mw in capacity (minor project) and one for large projects (major project).

LOAD - The amount of power needed to be delivered at a given point on an electric system.

MEGAWATT (Mw) - One thousand kilowatts.

MEGAWATT-HOURS - (Mwh) - One thousand kilowatt-hours.

NET HEAD - Also called effective head. The gross head less all hydraulic losses except those chargeable to the turbine.

PENSTOCK - A conduit used to convey water under pressure, to the turbines of a hydroelectric plant.

PLANT FACTOR - Ratio of the average load to the plants installed capacity, expressed as an annual percentage.

PONDAGE - The amount of water stored behind a hydroelectric dam of relatively small storage capacity used for daily or weekly regulation of the flow of a river.

POWER (ELECTRIC) - The rate of generation or use of electric energy, usually measured in kilowatts.

PUBLIC UTILITIES COMMISSION - In New Hampshire the state agency which oversees that adequate utility service is provided at fair and reasonable rates. The commission is an arm of the State Legislature and has the power to establish utility rates, audit utilities through financial reports, establish service territories for utilities and set standards of service for utilities.

RIPARIAN LAW - In New Hampshire where the developer's land borders upon a stream, his ownership will include the bed of the stream. The ownership of the land bordering the stream gives the developer ownership of the right to use the water, not ownership of the water. This may be contrasted to the Western Riparian law under which the right to use flowing water accrues in the first user rather than the Riparian or bordering owner.

RUN-OF-RIVER PLANT - A hydroelectric generating plant which depends chiefly on the flow of a stream or river as it occurs for generation purposes, as opposed to a storage project, which has sufficient storage capacity to carry water from one season to another. Some run-of-river projects have a limited storage capacity (pondage) which permits them to regulate streamflow on a daily or weekly basis.

SPECIAL BOARD - In New Hampshire Water Resources Board a committee which issues permits pertaining to dredging a watercourse for the purpose of increasing the depth of the impoundment area or filling to insure structural stability before construction. The Special Board includes members of the Water Resources Board, Fish and Game, and the Water Supply and Pollution Control Commission.

SPINNING RESERVE - Generating units operating at no load or at partial load with excess capacity readily available to support additional load.

STANDBY RESERVE - Generating equipment or other facilities reserved for use in case of outages or other emergency operating conditions. The generating equipment and other facilities may or may not be in service normally. This category of reserve should not be confused with spinning reserve.

SYNCHRONIZED OPERATION - An operation wherein electrical generating facilities are electrically connected and controlled to operate at the same frequency. It is synonymous with operation in parallel.

TAILWATER - The water surface elevation immediately downstream from a dam or hydroelectric power plant. A high tailwater condition reduces the hydraulic head and thus the efficiency of a hydroelectric generating station.

TRANSMISSION - The act or process of transporting electric energy in bulk.

TRANSMISSION GRID - An interconnected system of electric transmission lines and associated equipment for the movement or transfer of electric energy in bulk between points of supply and points of demand.

TURBINE - The part of a generating unit which is spun by the force of water or steam to drive an electric generator. The turbine usually consists of a series of curved vanes or blades on a central spindle.

WATER RESOURCE BOARD - In New Hampshire a state board established to oversee the conservation of water, the control of discharges from dams and all public water related projects. The Water Resources Board is also concerned with the registration of dams and will determine if the dam is a menace to public safety.

WHEELING - Transportation of electricity by a utility over its lines for another utility; also includes the receipt from and delivery to another system of like amounts but not necessarily the same energy.

REFERENCE LIST

1. U.S. Army Corps of Engineers, Jackson Mills Phase I Dam Inspection Report. Goldberg, Zoino, Dummicliiff & Assoc., Inc., February 1979.
2. Harris, Charles D., The Nashua River Canoe Guide, July 1976.
3. Nashua River Watershed Association, Plan for the Nashua River Watershed, 1972.
4. New Hampshire Fish and Game Department, Nashua River Biological Survey, 1974.
5. Department of Inland and Marine Fisheries, State of New Hampshire Inter-Department Communication, 10 July 1975.
6. Dingman, S. Lawrence, "Synthesis of Flow-Duration Curves for Unregulated Streams in New Hampshire", Water Resources Bulletin, December 1978, p. 1481.
7. Morris, Henry M. and James M. Wiggert, Applied Hydraulics in Engineering. New York: The Ronald Press Company, 1972.
8. New Hampshire State Legislature, Chapter 32 of the Laws of 1978 Special Session; Limited Electrical Energy Producers Act, Chapter 362-A in the New Hampshire Revised Statutes Annotated, 23 June 1978.
9. State of New Hampshire, Public Utilities Commission. Report on Rates for Sale of Power by Limited Electrical Energy Producers, 1979.
10. New Hampshire State Legislature, Chapter 411 of the Laws of 1979; Purchase of Output by Private Sector, 362-A:2-a amending RSA 362-A, 23 June 1979.
11. Energy Law Institute, Legal Obstacles and Incentives to the Development of Small Scale Hydroelectric Power in New Hampshire. Concord, New Hampshire: Franklin Pierce Law Center, January 1979.
12. Hillsborough County Registry of Deeds, Volume 1208, Page 74, 24 November 1948.